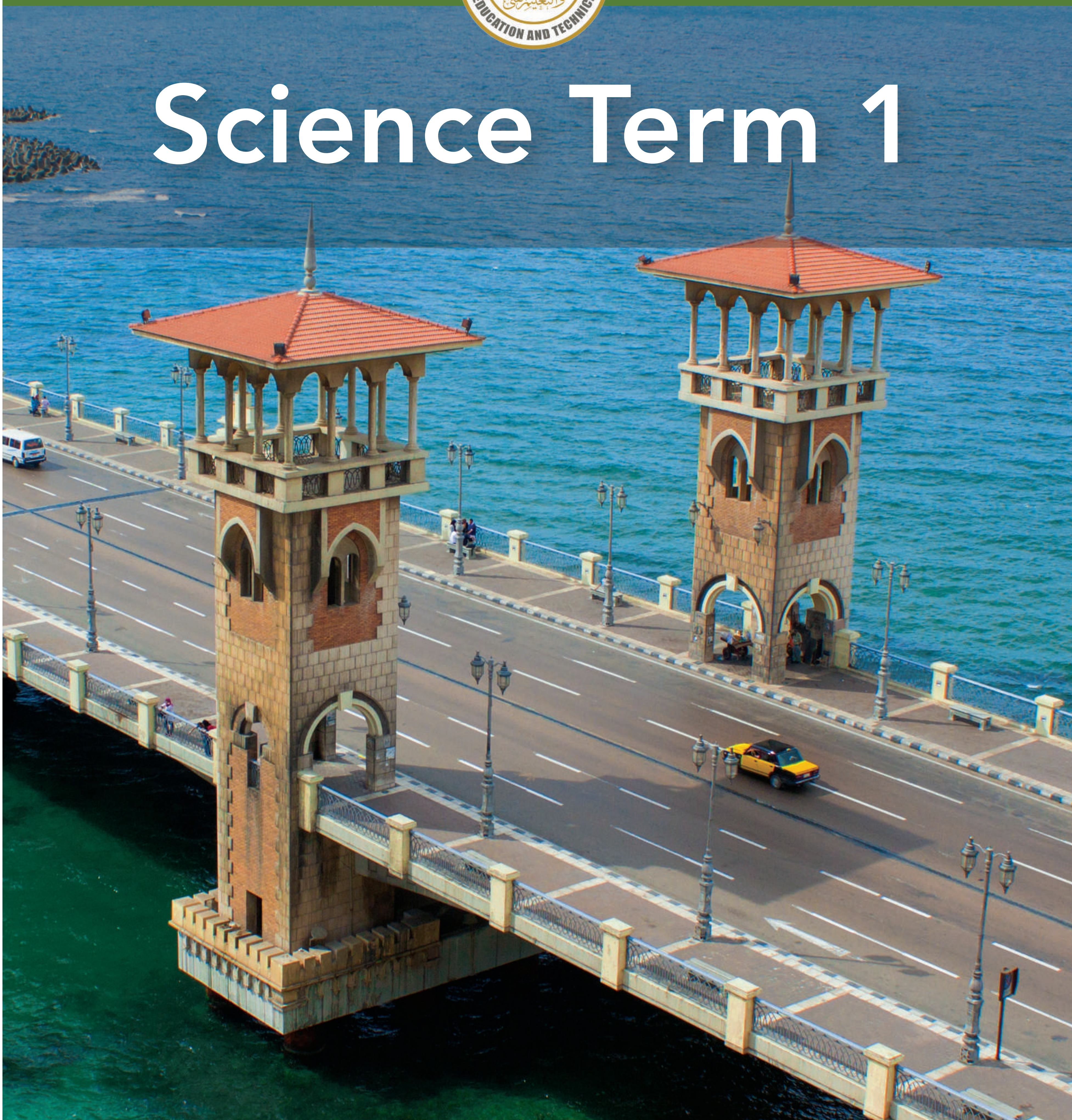
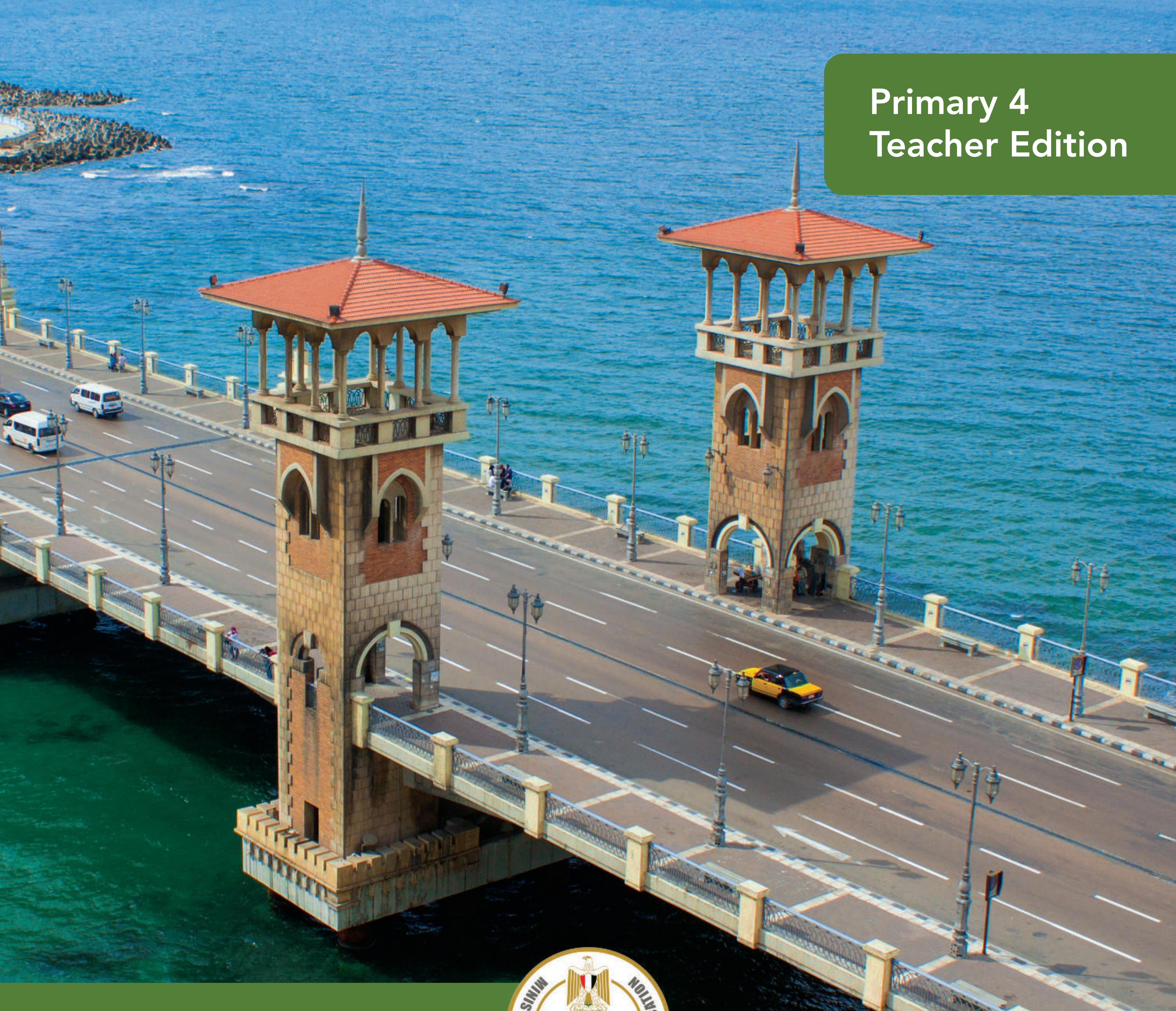
Primary 4
Teacher Edition

Science Term 1





Primary 4
Teacher Edition

MINISTRY OF EDUCATION AND TECHNICAL EDUCATION

Science Term 1

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FOREWORD

This is a pivotal time in the history of the Ministry of Education and Technical Education (MOETE) in Egypt. We are embarking on the transformation of Egypt's K-12 education system. We started in September 2018 with the rollout of KG1, KG2 and Primary 1, followed by Primary 2 and 3. In 2021 we have rolled out Primary 4, and we will continue with the rollout until 2030. We are transforming the way in which students learn to prepare Egypt's youth to succeed in a future world that we cannot entirely imagine.

MOETE is very proud to present this new series of textbooks, with the accompanying digital learning materials that captures its vision of the transformation journey. This is the result of much consultation, much thought and a lot of work. We have drawn on the best expertise and experience from national and international organizations and education professionals to support us in translating our vision into an innovative national curriculum framework and exciting and inspiring print and digital learning materials.

The MOETE extends its deep appreciation to its own "Center for Curriculum and Instructional Materials Development" (CCIMD) and specifically, the CCIMD Director and her amazing team. MOETE is also very grateful to the minister's senior advisors and to our partners including "Discovery Education," "National Geographic Learning" "Nahdet Masr," "Longman Egypt," UNICEF, UNESCO, and WB, who, collectively, supported the development of Egypt's national curriculum framework. I also thank the Egyptian Faculty of Education professors who participated in reviewing the national curriculum framework. Finally, I thank each and every MOETE administrator in all MOETE sectors as well as the MOETE subject counselors who participated in the process.

This transformation of Egypt's education system would not have been possible without the significant support of Egypt's current president, His Excellency President Abdel Fattah el-Sisi. Overhauling the education system is part of the president's vision of 'rebuilding the Egyptian citizen' and it is closely coordinated with the ministries of Higher Education & Scientific Research, Culture, and Youth & Sports. Education 2.0 is only a part in a bigger national effort to propel Egypt to the ranks of developed countries and to ensure a great future to all of its citizens.

Words from the Minister of Education & Technical Education

It is my great pleasure to celebrate this extraordinary moment in the history of Egypt where we continue to launch a new education system designed to prepare a new Egyptian citizen proud of his Egyptian, Arab and African roots — a new citizen who is innovative, a critical thinker, able to understand and accept differences, competent in knowledge and life skills, able to learn for life and able to compete globally.

Egypt chose to invest in its new generations through building a transformative and modern education system consistent with international quality benchmarks. The new education system is designed to help our children and grandchildren enjoy a better future and to propel Egypt to the ranks of advanced countries in the near future.

The fulfillment of the Egyptian dream of transformation is indeed a joint responsibility among all of us; governmental institutions, parents, civil society, private sector and media. Here, I would like to acknowledge the critical role of our beloved teachers who are the role models for our children and who are the cornerstone of the intended transformation.

I ask everyone of us to join hands towards this noble goal of transforming Egypt through education in order to restore Egyptian excellence, leadership and great civilization.

My warmest regards to our children who will begin this journey and my deepest respect and gratitude to our great teachers.

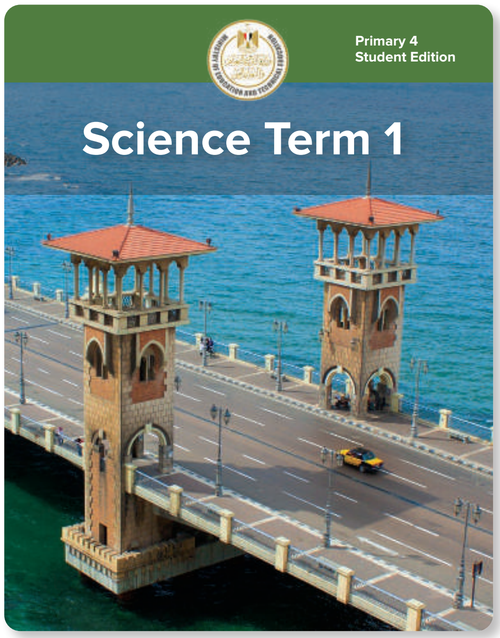
Dr. Tarek Galal Shawki

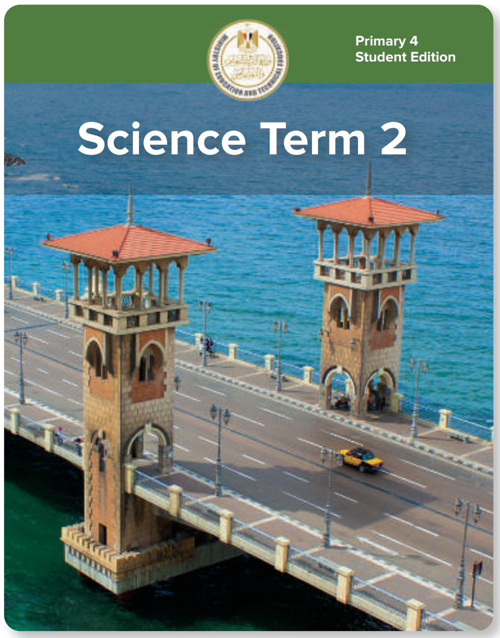
Minister of Education & Technical Education

Welcome to Primary 4 Science Techbook!

Students all over the world are natural explorers, filled with curiosity and innovative ideas. Science helps all of us understand and make sense of the world. Scientific reasoning helps students search for solutions to real-world challenges and to ask new questions as learners and thinkers. As you read the new Primary 4 student and teacher instructional resources, keep a few things in mind:

- The Primary 1 through Primary 3 multidisciplinary curriculum, Discover, implemented across Egypt starting from 2018 to 2020, helped lay a foundation for young students to inquire, observe, and think like scientists.
- The Primary 4 science content is more challenging than ever before, however students are aided by their experience in the new KG through Primary 3 curriculum. To help all students reach the challenging expectations in Preparatory and Secondary years, Primary 4 Science Techbook offers more opportunities for deeper learning, more opportunities for hands-on investigation, and more practice using the skills necessary to think, observe, analyze, and evaluate like scientists.
- The Primary 4 science curriculum is called a Techbook™. The Techbook is more than just print. It is a 21st-century instructional resource designed to inspire and empower all students through digital and print learning. The program has content in both print and digital locations so that students can learn whether they have access to the print book or digital version.





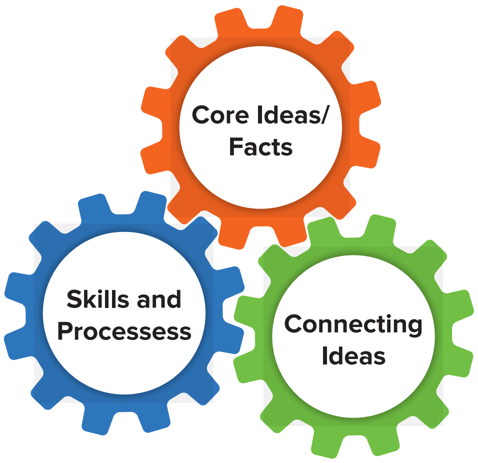
Program Philosophy

The Primary 4 Science Techbook was designed and written to align to the Ministry of Education Primary 4 science learning standards. These standards are internationally benchmarked, providing students in Egypt with a rigorous framework of learning targets.

The first step in building the Primary 4 framework was the adoption of new standards and specific grade-level indicators for learning in physical science, life science, earth and space science, environmental science, and engineering design and processes. These standards are integrated across three dimensions:

- disciplinary core ideas (such as energy transformations or the structure of cells),
- science skills and processes (such as asking questions to plan investigations, developing models, communicating scientific information), and
- connecting ideas that carry over across disciplines (such as cause and effect, systems, patterns).

This approach to teaching science is referred to as three-dimensional learning. Science is much more than an accumulation of facts; it is an intersection of three dimensions: facts, skills and processes, and connecting ideas.



- Core ideas have broad importance, are key organizing concepts, and provide tools for complex ideas.
- Skills and processes combine the behaviors that scientists engage in and the key engineering practices that they use.
- Connecting ideas link the different domains of Science.

The intersection of these three dimensions provides the foundation for the scientific content in Primary 4. The structure of Primary 4 Science Techbook also embodies the Ministry's shifts in the Framework for Education 2.0., specifically focusing on:

- student-centered learning;
- providing opportunities for authentic investigation by prioritizing hands-on learning; and
- creating globally prepared students by integrating career, technology, entrepreneurship, and life skills.

Student-Centered Learning: Wonder • Learn • Share

Students are at the heart of Primary 4 science instruction. Students act as scientists and engineers to investigate problems and construct solutions. Students conduct research and develop scientific explanations for phenomena. Students build and test prototypes and determine the best solutions based on the collection and analysis of data. By exploring real-world situations and articulating original questions with teacher support, students actively construct scientific knowledge and identify ways to improve and extend human capabilities.

To help drive a student-centered approach to learning, Primary 4 Science Techbook is organized by the Wonder-Learn-Share sequence. This sequence may be a change from how science has been taught previously, but having students think about the natural phenomena they are investigating before they dig into the learning helps them retain more knowledge and develop the skills and disposition of a scientist and a learned citizen.

Wonder starts off every concept by igniting natural curiosity with relatable content that inspires students to ask the questions they want to explore about the inner workings of the world around us.

Learn helps students find answers to the questions posed in Wonder. Students explore, observe, predict, and investigate the phenomena of science through rich texts, Hands-On Investigations and experiments, and engaging interactive resources.

Share requires students to summarize their learning with their peers and teacher. Students develop solutions to real-world challenges and write scientific explanations that include their evidence-based reasoning.

Hands-On Learning: All Students as Experimental Scientists

Hands-On Investigations (HOIs) are a foundational component of Primary 4 Science Techbook. Hands-On Investigations require students to investigate scientific ideas, build scientific understanding through observation, and practice the skills of doing science that develop their knowledge and effective solutions.

A materials list for each HOI is included in multiple locations: at point-of-use in digital, in the print Teacher Edition, and in the print Student Edition. Science materials were chosen to be easily accessible and mostly familiar to both students and teachers. Each materials list should be reviewed well in advance of the date of classroom use to ensure all materials are available. To assist teachers in familiarizing themselves with the HOIs, a series of teacher support instructional videos are included with this product.

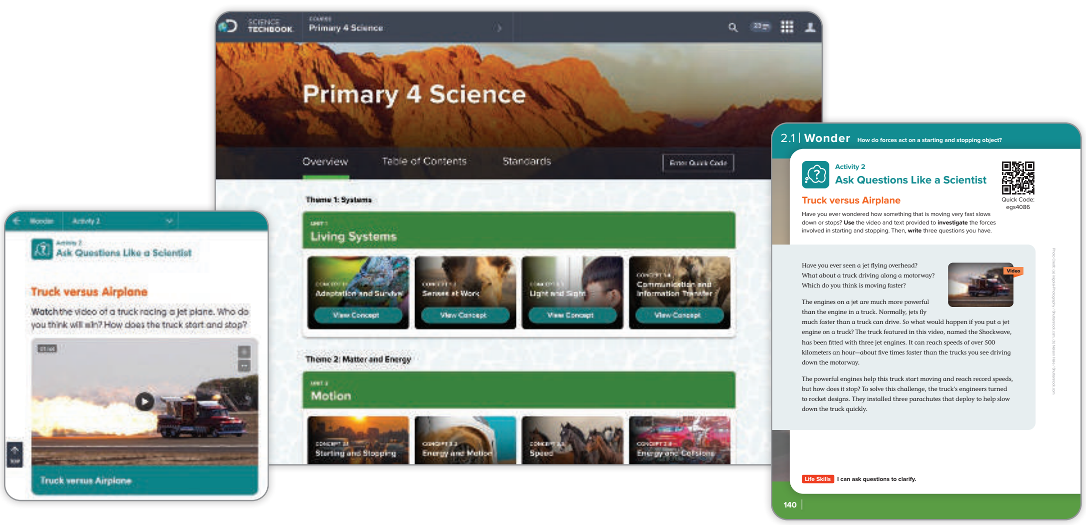
Globally Prepared Students: Action-Packed, Real-World Challenges

To prepare students with the skills they need to succeed in an interconnected, global society, Primary 4 Science Techbook integrates skills and concepts from career fields, technology, entrepreneurship, and life skills.

- **Careers:** The study of science, technology, engineering, and math (STEM) fields and pathways to STEM careers provides an ongoing emphasis on careers and real-world applications for learning.
- **Technology:** Students examine the structure and function of individual technologies as well as both the role of technology in society and the role of society in the development and use of technology.
- **Entrepreneurship:** In the Share portion of each concept, students encounter the skills of entrepreneurship, including discovering opportunities, generating creative ideas, setting a vision for transforming ideas into valuable activities, and using ethical and sustainable thinking.
- **Life Skills:** Building on introductions made through Primary 3, Primary 4 Science Techbook highlights opportunities to apply and practice the life skills throughout the instructional sequence.

Course Structure

The Primary 4 Science Techbook is a comprehensive teaching and learning package, featuring an easy-to-use digital platform, an interactive print Student Edition, and a print Teacher Edition. This print Teacher Edition provides guidance for teachers to implement high-quality, three-dimensional learning through Hands-On Investigations, lab investigations, and print and digital assets. This flexibility of resources supports the many variations of classroom settings, so teachers can implement standards-based lessons no matter their particular situation. The digital and print resources work seamlessly together, allowing students to both express thinking on paper and explore ideas and concepts digitally.



Themes

The Primary 4 Science Techbook is organized into four themes that form the structure of science courses from Primary 4 through Primary 6. In each grade, the theme is studied through an applied topic, represented by units within this curricular resource. Each unit launches with an engaging, real-world anchor phenomenon to captivate students. The anchor phenomena will inspire students to ask questions they themselves want to investigate. At the end of the learning progression, students solve problems related to the anchor phenomenon with the culminating unit project. The themes and Primary 4 units are as follows:

Theme	Primary 4 Unit
Systems	Living Systems
Matter and Energy	Motion
Protecting Our Planet	Energy and Fuels
Change and Stability	Shifting Surfaces

Concepts

Within each unit there are four concepts, which are the heart of the learning process. The concept helps students understand the anchor phenomena with the development of learning standards through the use of text, multimedia, Hands-On Investigations, and STEM projects. Every concept:

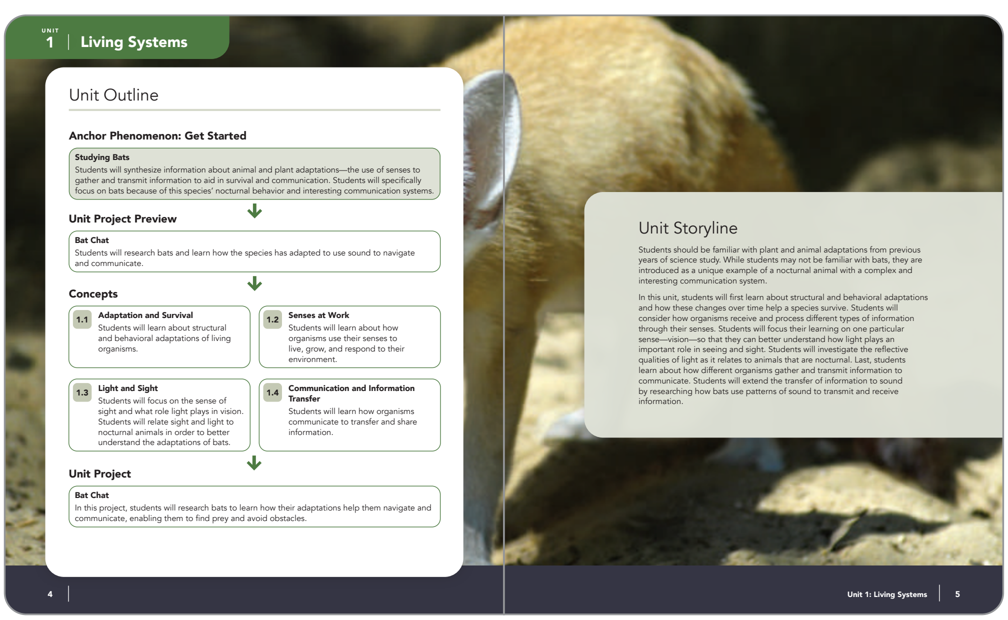
- launches with an investigative phenomenon and a related Can You Explain? question;
- provides multiple pathways for students to demonstrate their learning, including the creation of scientific explanations in the claim, evidence, reasoning format;
- encourages STEM career exploration; and
- helps students summarize their understanding through a required unit project.

Activities

Each concept is comprised of a series of activities or learning experiences. The Recommended Pathway clearly outlines the sequence and duration of each learning activity. Activities vary in length and many daily lessons include several activities that are woven together to create rigorous learning experiences for students.

Unit and Concept Overviews

Each unit in the Teacher Edition begins with a storyline. The storyline summarizes the big picture of how the unit anchor phenomena, supporting concepts, and culminating unit project interact with and build on each other. Each concept provides pacing directions, differentiation, and STEM and entrepreneurship connections.



Approach

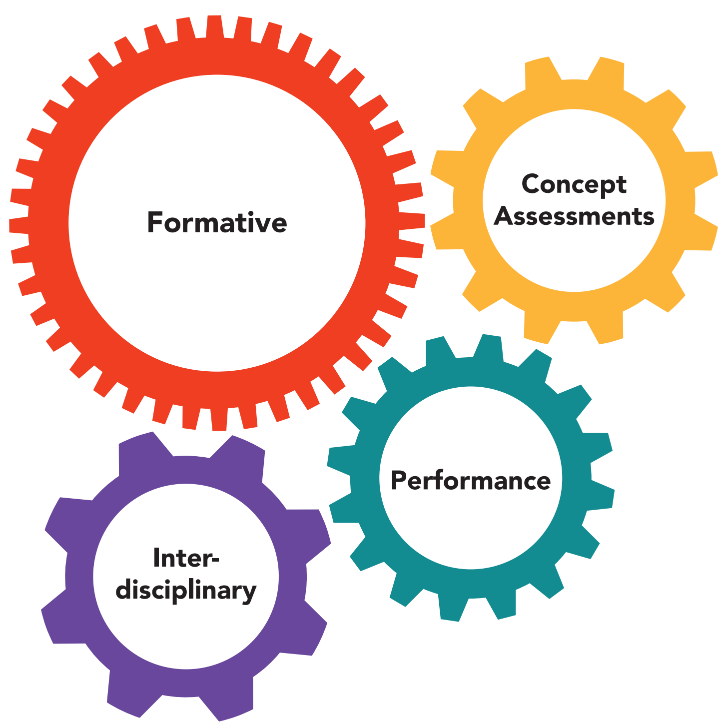
Using Phenomena to Spark Curiosity and Learning

Throughout this course, real-world and engaging phenomena are used to pique students' curiosity.

This phenomenon-based instructional approach shifts the focus from learning about a topic to uncovering why or how a scientific event happened. At the unit level, an anchor phenomenon sets a purpose for learning across concepts. A unit project, highlighted at the beginning of each unit, expects students to return to the anchor phenomenon at the end of the unit. The unit project summarizes student learning across the unit storyline and serves as a summative assessment of three-dimensional learning.

Each concept also begins with a smaller, real-world investigative phenomenon to inspire students to uncover the scientific principles behind the phenomenon. Students dive into the remainder of the content using a variety of scientific practices, including asking questions, observing, analyzing information, and designing solutions. Students return to the investigative phenomenon at the end of each concept, using the scientific skills and practices to provide evidence and reasoning for their claims.

Approach to Assessment



Assessments are an integral part of instruction that provide evidence of proficiency and student success. By using a variety of assessment formats and data sources, a comprehensive program can serve three distinct functions:

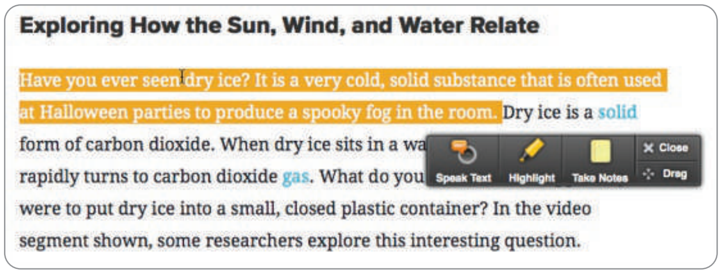
- Monitor students' progress and provide feedback to promote student learning
- Make instructional decisions to modify teaching to facilitate student learning
- Evaluate students' achievement to summarize and report students' demonstrated understanding at a particular point in time

In the Primary 4 Science Techbook, assessments are embedded throughout as formative, summative, performance-based (project-based), and interdisciplinary projects.

Science Techbook Features

Tools and Text Features

The tools within every concept in Primary 4 Science Techbook support differentiation for the core instructional activities and cater to the different learning preferences of diverse learners. In the digital core interactive text, students and teachers can have text read aloud, highlight important information, or annotate content with sticky notes. Select the text in any concept, and a reader tool will appear.



Digital Teacher Materials

In digital Primary 4 Science Techbook, teachers can not only easily see the student view of content, but they can also access additional support using the Teacher Presentation Mode toggle. Teacher notes, featuring both the instructional focus and recommended strategy, are included with each activity and are visible to teachers only. In addition, teachers can view sample responses to student questions, and Hands-On Investigations include a teacher's guide with detailed procedural notes.

Flexible Learning Environment

With the evolution of technology, today's students expect information to be available differently than previous generations. Students are accessing information in shorter segments, streaming digital shows, and reading posts through social media. The Primary 4 Science Techbook taps into students' preferences of consuming digital content and provides highly engaging, standards-based content guaranteed to inspire and encourage students to delve deeper into science.

Through every step of the learning cycle, the Primary 4 Science Techbook features diverse and rich multimedia resources: video, images, audio, interactives, virtual labs, online models, animations, rich informational text, and more. Engaging science content blends entertainment with education to motivate students to investigate real-world phenomena. Virtual labs and online models allow students to quickly manipulate variables to test their ideas in an online environment.

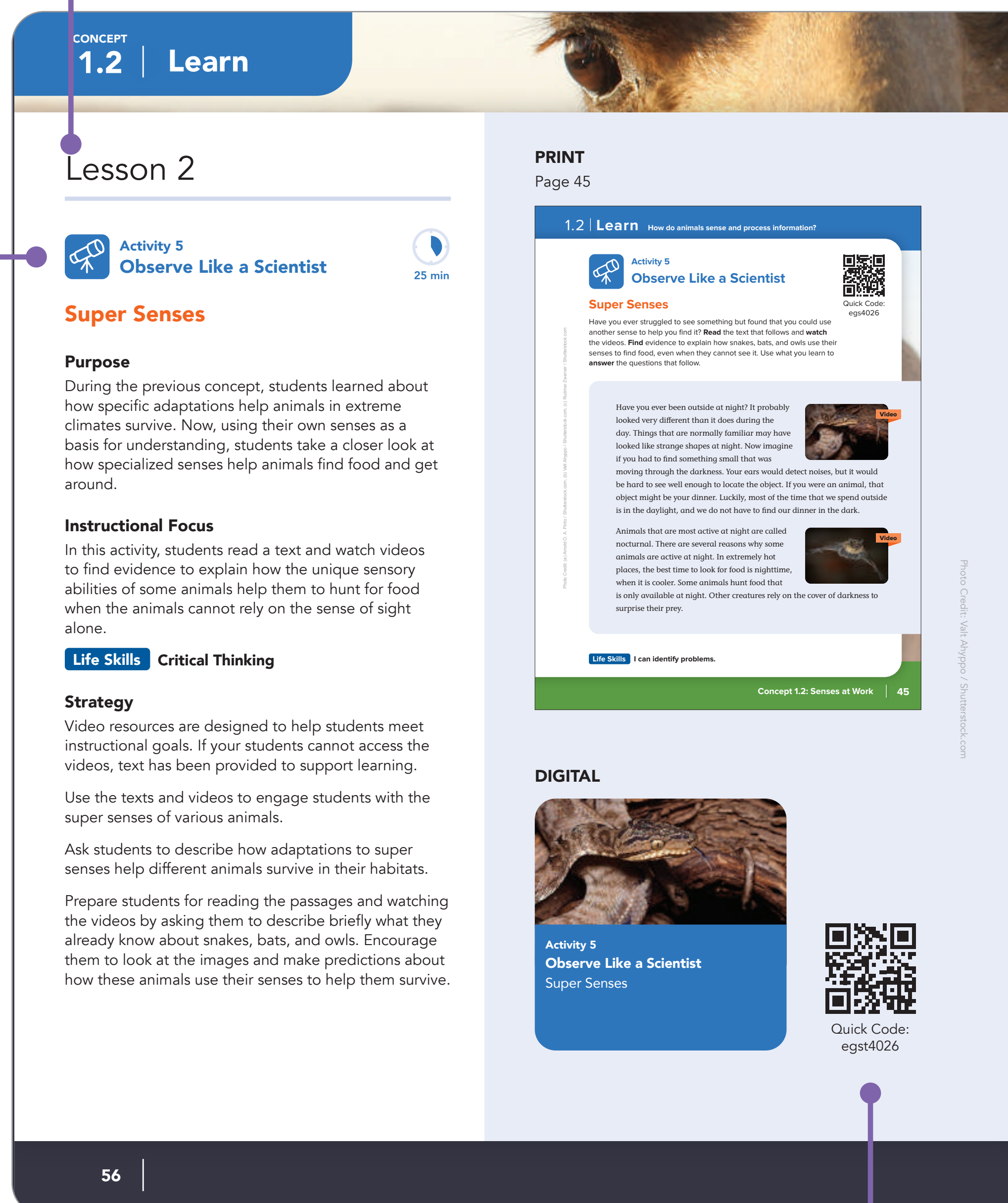
Concept Daily Instruction Features

Lessons

Instruction is presented in 45-minute segments by lesson.

Activities

Within each day, strategies for a variety of activity types guide teachers through possible means of classroom implementation.



CONCEPT 1.2 | Learn

Lesson 2

Activity 5
Observe Like a Scientist

25 min

Super Senses

Purpose
During the previous concept, students learned about how specific adaptations help animals in extreme climates survive. Now, using their own senses as a basis for understanding, students take a closer look at how specialized senses help animals find food and get around.

Instructional Focus
In this activity, students read a text and watch videos to find evidence to explain how the unique sensory abilities of some animals help them to hunt for food when the animals cannot rely on the sense of sight alone.

Life Skills Critical Thinking

Strategy
Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Use the texts and videos to engage students with the super senses of various animals.

Ask students to describe how adaptations to super senses help different animals survive in their habitats.

Prepare students for reading the passages and watching the videos by asking them to describe briefly what they already know about snakes, bats, and owls. Encourage them to look at the images and make predictions about how these animals use their senses to help them survive.

PRINT
Page 45

1.2 | Learn How do animals sense and process information?

Activity 5
Observe Like a Scientist

Quick Code: egs4026

Super Senses

Have you ever struggled to see something but found that you could use another sense to help you find it? **Read** the text that follows and **watch** the videos. **Find** evidence to explain how snakes, bats, and owls use their senses to find food, even when they cannot see it. Use what you learn to **answer** the questions that follow.

Have you ever been outside at night? It probably looked very different than it does during the day. Things that are normally familiar may have looked like strange shapes at night. Now imagine if you had to find something small that was moving through the darkness. Your ears would detect noises, but it would be hard to see well enough to locate the object. If you were an animal, that object might be your dinner. Luckily, most of the time that we spend outside is in the daylight, and we do not have to find our dinner in the dark.

Video

Animals that are most active at night are called nocturnal. There are several reasons why some animals are active at night. In extremely hot places, the best time to look for food is nighttime, when it is cooler. Some animals hunt food that is only available at night. Other creatures rely on the cover of darkness to surprise their prey.

Video

Life Skills I can identify problems.

Photo Credit: (a) Arnold O. A. Pinto / Shutterstock.com, (b) Valt Ahyppo / Shutterstock.com, (c) Rudmer Zwerver / Shutterstock.com

Concept 1.2: Senses at Work | 45

DIGITAL

Activity 5
Observe Like a Scientist
Super Senses

Quick Code: egst4026

Photo Credit: Valt Ahyppo / Shutterstock.com

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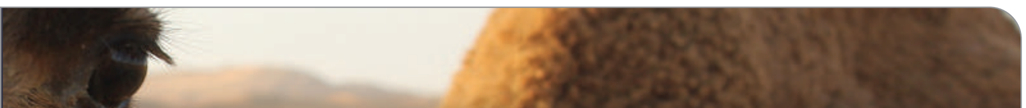
Quick Digital Access

Throughout the print Student and Teacher Editions, QR codes and short links indicate opportunities to go digital to deepen learning through rich media or assessment opportunities.



PRINT
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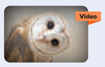
1.2 | **Learn** How do animals sense and process information?



How do these animals hunt without much available light? Super sensory adaptations allow these animals to navigate the darkness safely and find food sources. Snakes have the ability to sense heat using a specialized body part in their face. This means snakes can detect warm-blooded prey in complete darkness. Bats rely on echolocation. This ability to bounce sounds off objects helps bats find insects in the dark. Using the "echo" that returns when the sounds they make bump into objects, bats can create a map in their mind that leads them right to the food. Owls have both extraordinary sight and hearing. Bowl-shaped faces and specialized head feathers direct distant sounds directly into the owl's ears. Sometimes animals making noises are hidden in the grass or beneath the snow. Large eyes allow the owl to see tiny, far-away movements. The ability to turn their heads nearly all the way around lets owls search for prey in every direction.

Snakes use heat to hunt. Why would this special sense be useful to snakes?
Snakes are unable to see at night, so they use their sense of heat to find their prey.

How do bats catch gnats in the dark?
Bats are nocturnal and hunt for food at night. They can't see very well in the dark, so they use echolocation, or echoes, to help them hear where their food is.

How does the shape of an owl's head help it hear what it cannot see?
The owl's bowl-shaped face picks up distant sounds and amplifies them.

Lesson 2, *continued*

Lead a discussion on the questions posed. Have students share answers with the class before writing individual answers. Encourage students to expand on their thinking by asking questions such as, *Can you say more about that? What do you mean by that? What specific examples from the videos support what you are saying?*

ASK

- *Snakes use heat to hunt. Why would this special sense be useful to snakes?* *Snakes are unable to see at night, so they use their sense of heat to find their prey.*
- *How do bats catch gnats in the dark?* *Bats are nocturnal and hunt for food at night. They can't see very well in the dark, so they use echolocation, or echoes, to help them hear where their food is.*
- *How does the shape of an owl's head help it hear what it cannot see?* *The owl's bowl-shaped face picks up distant sounds and amplifies them.*

Differentiation

ADVANCED LEARNERS

Challenge students to research why different animals may have a better sense of touch, smell, sight, hearing, or taste than humans.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- What would I organize differently next year?

Differentiated Instruction

Primary 4 Science Techbook allows teachers to differentiate instruction, degrees of readiness, and interests. Techbook also offers resources to help vary content, process, product, and learning environment through the core instructional pathway. Point-of-use teacher notes are integrated to support approaching and advanced learners.

Built upon the principles of Universal Design for Learning, Primary 4 Science Techbook features a variety of content types, including images, video, audio, text, interactives, and Hands-On Investigations. These multimedia resources, included in both digital and print, provide multiple representations of the content and the flexibility for teachers to assign targeted content to whole groups or individual students.

Teacher Reflection

Throughout each concept, questions encourage teachers to consider how activities are working in their classrooms and how well students are accessing the material.

Globally Prepared Students: A Focus on STEM, Career, Life Skills, and Entrepreneurship

Preparing students in Egypt to be globally competitive is a major focus of Education 2.0. Solving many of the challenges facing our world today and tomorrow will require integrating skills and knowledge from science, technology, engineering, and math, as well as core life skills. The Primary 4 Science Techbook introduces age-appropriate examples of these challenges that align to Egyptian Issues such as citizenship, globalization, and the environment and development. STEM applications are highlighted throughout this course in Share activities, STEM Project Starters, and Interdisciplinary Projects.

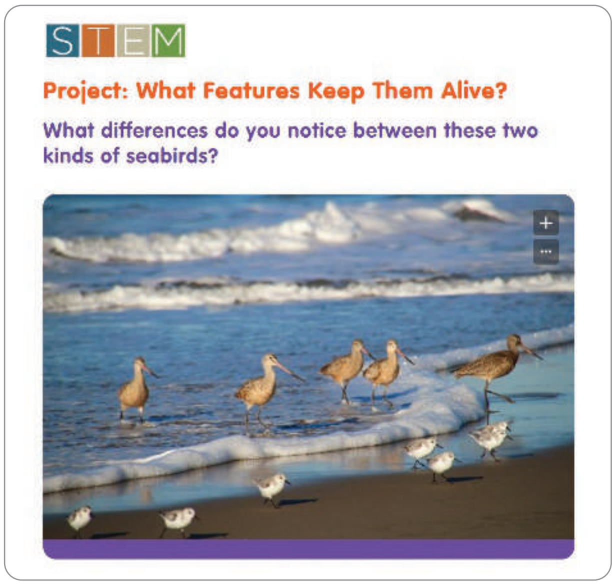
Share Activities

At the end of each concept, students synthesize learning in a series of Share activities. Students construct scientific explanations related to the opening Can You Explain? question (or other student-generated questions from Wonder). Students consider real-world applications by exploring career and entrepreneurship connections. And finally, students summarize learning by thinking about, writing about, and reviewing connections to the big ideas of the unit.

ENTREPRENEURSHIP
Entrepreneurs set goals by determining priorities and action plans. As you read about field biologists, think of ways their work might require the setting of short, medium, and long term goals. How might field biologists and researchers need to adapt to unexpected changes?

STEM Project Starters

The Egypt Primary 4 Science curriculum builds on the multidisciplinary Discover from Primary 1 through Primary 3, using an integrated approach to life skills, career connections, and entrepreneurship through a STEM focus. Extensions found in the Share section of the digital Techbook, called STEM Project Starters, highlight the connections between students' work and current and future STEM careers. The focus on entrepreneurship, career skills, and real-world challenges allow students an opportunity to innovate and develop life skills of creativity, problem-solving, and self-expression.

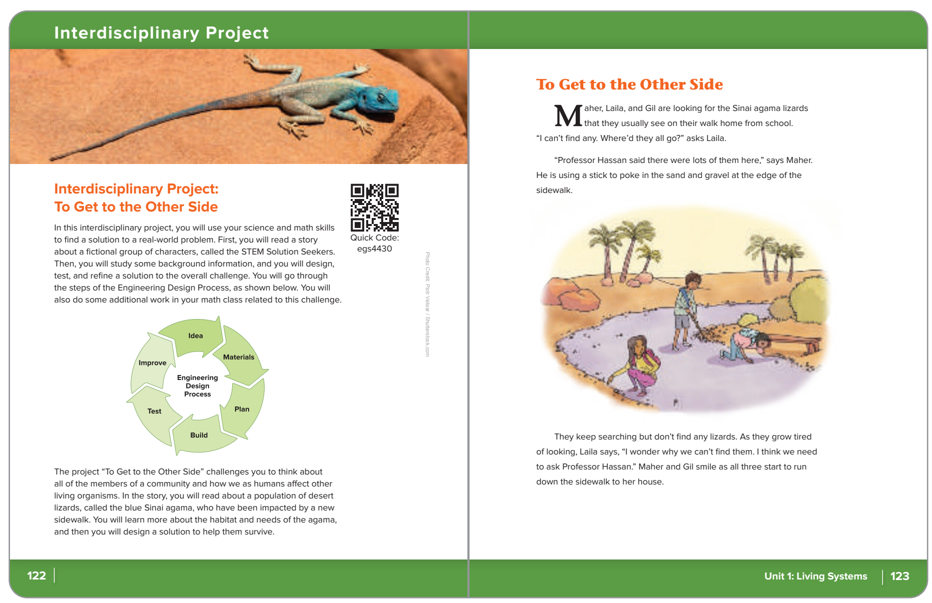


The STEM Project Starters require students to connect math, technology, and engineering to their understanding of science concepts. STEM Project Starters focus on multiple aspects of STEM and challenge students to apply in new ways the content and learning from each concept.

Interdisciplinary Projects: Content and Real-World Connections

A unique addition to the Primary 4 Science Techbook is the Interdisciplinary Projects, provided for students once per term. These Interdisciplinary Projects are based on real-world challenges derived from the United Nations Sustainable Development Goals. Countries across the globe adopted these Sustainable Development Goals in 2015 (with annual monitoring and tracking) to "end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030.[1]"

For students to authentically connect academic content, practice life skills, and deeply understand the Egyptian Issues, we must provide opportunities for students to search for their own solutions. The Interdisciplinary Projects allow students to do just that. Students are presented with a challenge and then given the opportunity to generate ideas using knowledge and skills from science, mathematics, and other disciplines. Students work with classmates to design a solution to build, test, and refine using the Engineering Design Process.



The first Interdisciplinary Project, "To Get to the Other Side," challenges students to think about sustainability in a community that includes humans and other living organisms. Students consider the needs of a reptile, the blue Sinai agama, and how these lizards interact with a school community's needs for a new sidewalk.

[1] https://www.undp.org/content/undp/en/home/sustainable-development-goals.html

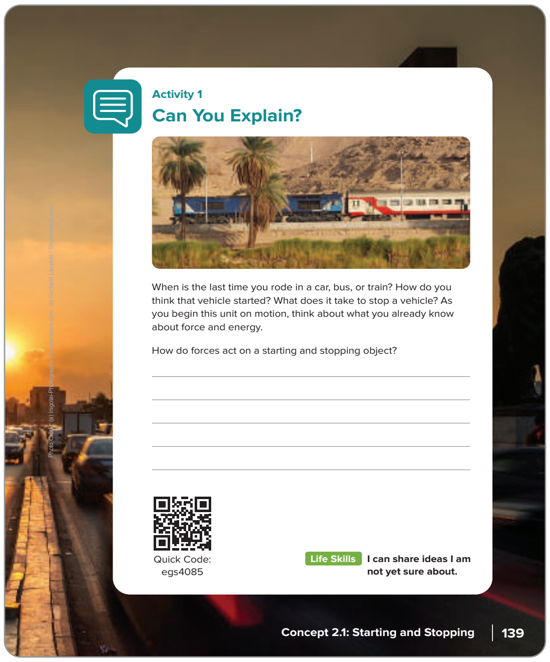
The Writing Process and Science Connection

Writing is an important part of science because it is how real scientists document and communicate their ideas, activities, and findings to others. Primary 4 Science Techbook engages students in many kinds of writing, especially argumentation. Argumentative writing in science calls for the use of evidence, often requiring students to read across several texts, watch videos and other media, and integrate findings from Hands-On Investigations.

Informational texts throughout Techbook help students strengthen their reading comprehension skills and develop both academic and discipline-specific language, while multimedia resources provide context and assist students in accessing the text. Primary 4 Science Techbook also authentically incorporates the writing process and expects students to use speaking and listening skills to demonstrate their understanding of science.

During the Share portion of each concept, students are asked to integrate their ideas in writing. Using the claim-evidence-reasoning structure, students learn to use evidence as a natural part of writing like a scientist. The first unit builds student skill in connecting claims and evidence. By the second unit, students expand on this skill to include articulation of both the evidence and reasoning that back up a claim. Both the digital and the print resources will engage students in the practice of this type of writing.

Teacher Reflection: How are you developing your students into scientific readers?


Activity 1

Can You Explain?

When is the last time you rode in a car, bus, or train? How do you think that vehicle started? What does it take to stop a vehicle? As you begin this unit on motion, think about what you already know about force and energy.

How do forces act on a starting and stopping object?

Quick Code: egs4085

Life Skills I can share ideas I am not yet sure about.

Concept 2.1: Starting and Stopping | 139

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- Would I organize this differently next year?

Building Academic Language of All Students

Reading and writing success in science depends on the ability of students to understand not only the definition of vocabulary words, but also how the academic language connects ideas, adds details, or organizes the text. Academic language is supported and emphasized through strategies for learning vocabulary, frequent vocabulary use in various texts, and formative assessment items.

Notes:

Primary 4 Science Scope and Sequence

Primary 4 • THEME	1	2	3	4
SCIENCE				
A. Skills and Processes				
1. Demonstrate thinking and acting inherent in the practice of science.				
a. Identify scientific and non-scientific questions.	•	•	•	•
b. Plan and carry out simple investigations to collaboratively produce data that answers a question.	•	•	•	•
c. Represent data in tables and graphs, compare the styles of representation.	•	•	•	•
d. Construct an argument with evidence and data.	•	•	•	•
e. Develop and/or use models to explain natural phenomena.	•	•	•	•
f. Use multiple texts to answer questions or explain phenomena.	•	•	•	•
g. Use multiple texts to answer questions or explain phenomena.	•	•	•	•
B. Earth and Space Science				
1. Use scientific skills and processes to explain the chemical and physical interactions of the environment, Earth, and the universe that occur over time.				
a. Describe the effects of some weathering factors (such as water or wind erosion). 1) Identify evidence from patterns in rock formations to support an explanation for changes in a landscape over time (such as a river changing course over time or the effect of a wind barrier being removed).				•
b. Identify connections between Earth's geologic processes and three main types of rocks: 1) Igneous (formed from volcanic activity) 2) Sedimentary (formed via deposition) 3) Metamorphic (formed as the result of change)				•

	1	2	3	4
C. Life Science				
1. Use scientific skills to describe the essential needs of a living organism (plants and animals, including humans).				
a. Classify plants, animals, and other living organisms using physical and other observable characteristics of the organisms. 1) Explain the objectives and purpose of classifications. 2) Provide examples of living organisms with similar physical characteristics.	•			
b. Propose ways to maintain the health and safety of the digestive system. 1) Relate the organs involved in digestion to their function in the digestive system. 2) Explain how the organs in the digestive system work together to break down and absorb food for energy. 3) Identify potential sources of damage related to the digestive system.	•			
c. Advocate for how to maintain the health and safety of the air living organisms rely on for life (for example, design a public message or advertising campaign). 1) Relate the organs involved in breathing to their function in the respiratory system for multiple species (such as humans and fish). 2) Identify threats to healthy respiration (such as smoking or causes of air and water pollution).	•		•	
d. Analyze examples of how animals receive different types of information through their senses, process the information in their brains, and respond to the information in different ways. 1) Explain how structural adaptation relating to senses helps organisms survive in specific environments. 2) Use evidence to explain that multiple adaptations or organs work together in systems to help organisms gather information needed to survive in specific habitats. 3) Develop a model that shows how organisms respond to changes in their habitat over time.	•		•	

Primary 4 • THEME	1	2	3	4
D. Physical Science				
1. Use scientific skills and process to explain the interactions of matter and energy and the energy transformations that occur.				
a. Use evidence to construct an explanation relating the speed of an object to the energy of that object. 1) Explain the basic connection between energy and movement.		•		•
b. Ask questions and predict outcomes about the changes in energy that occur when objects collide.		•		•
c. Summarize observations of how energy can be transferred from place to place by sound, light, heat, and/or electric currents. 1) Identify various forms of energy. 2) Describe everyday examples of energy changing from one form to another. 3) Explain how some everyday devices transform energy. 4) Identify the energy transformations that occur when energy is used to run a device in the home or school.	•	•	•	
d. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. [Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and a passive solar heater that converts light into heat.]		•	•	

	1	2	3	4
E. Environmental Science				
1. Use scientific skills and process to explain the interactions of environmental factors (living and nonliving and analyze their impact on a local and global scale.				
a. Analyze how the use of fuels derived from natural resources affect the environment. *[Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]* 1) Identify and compare various renewable and nonrenewable sources of energy in the environment. 2) Diagram the role of fuel sources in producing electricity. 3) Describe how the use of energy and fuels affects the environment. 4) Propose local or national solutions for reducing the impact of energy and fuel use (such as decreasing local energy consumption or increasing nationwide use of alternative energy sources).			•	
F. Engineering Design and Process				
a. With support, explain the characteristics and scope of technology.		•		
b. With support, explain the role of society in the development and use of technology.		•		
c. Define a simple design problem that can be solved through the development of an object, tool, process, or system.	•			•
d. Apply the design process with support, using tools and materials to plan and/or build a device that solves a specific problem.		•		•
e. Analyze data from tests of an object or tool to determine whether it works as intended.		•		
f. Assess the impact of products and systems with support.	•			•

UNIT 1 | Living Systems

Photo Credit: Christian Musat / Shutterstock.com

Theme 1 | Systems

Unit 1
Living Systems

Learning Indicators

Throughout this unit, students will work toward the following learning indicators:

Primary 4 • CONCEPT	1.1	1.2	1.3	1.4
SCIENCE				
A. Skills and Processes				
1. Demonstrate thinking and acting inherent in the practice of science.				
a. Identify scientific and non-scientific questions.	•	•	•	•
b. Plan and carry out simple investigations to collaboratively produce data that answers a question.	•	•	•	•
c. Represent data in tables and graphs, compare the styles of representation.			•	•
d. Construct an argument with evidence and data.	•	•	•	•
e. Develop and/or use models to explain natural phenomena.	•	•	•	•
f. Use multiple texts to answer questions or explain phenomena.	•	•	•	•
g. Communicate scientific information orally and in written formats.	•	•	•	•
C. Life Science				
1. Use scientific skills to describe the essential needs of a living organism (plants and animals, including humans).				
a. Classify plants, animals, and other living organisms using physical and other observable characteristics of the organisms. 1) Explain the objectives and purpose of classifications. 2) Provide examples of living organisms with similar physical characteristics.	•			
b. Propose ways to maintain the health and safety of the digestive system. 1) Relate the organs involved in digestion to their function in the digestive system. 2) Explain how the organs in the digestive system work together to break down and absorb food for energy. 3) Identify potential sources of damage related to the digestive system.	•			

	1.1	1.2	1.3	1.4
c. Advocate for how to maintain the health and safety of the air living organisms rely on for life (for example, design a public message or advertising campaign). 1) Relate the organs involved in breathing to their function in the respiratory system for multiple species (such as humans and fish). 2) Identify threats to healthy respiration (such as smoking or causes of air and water pollution).	•			
d. Analyze examples of how animals receive different types of information through their senses, process the information in their brains, and respond to the information in different ways. 1) Explain how structural adaptation relating to senses helps organisms survive in specific environments. 2) Use evidence to explain that multiple adaptations or organs work together in systems to help organisms gather information needed to survive in specific habitats. 3) Develop a model that shows how organisms respond to changes in their habitat over time.	•	•	•	•
D. Physical Science				
1. Use scientific skills and processes to explain the chemical and physical interactions of the environment, Earth, and the universe that occur over time.				
c. Summarize observations of how energy can be transferred from place to place by sound, light, heat, and/or electric currents. 1) Identify various forms of energy. 2) Describe everyday examples of energy changing from one form to another.			•	•
F. Engineering Design and Process				
c. Define a simple design problem that can be solved through the development of an object, tool, process, or system.			•	•
f. Assess the impact of products and systems with support.	•			

Unit Outline

Anchor Phenomenon: Get Started

Studying Bats

Students will synthesize information about animal and plant adaptations—the use of senses to gather and transmit information to aid in survival and communication. Students will specifically focus on bats because of this species' nocturnal behavior and interesting communication systems.

Unit Project Preview

Bat Chat

Students will research bats and learn how the species has adapted to use sound to navigate and communicate.

Concepts

1.1 Adaptation and Survival

Students will learn about structural and behavioral adaptations of living organisms.

1.2 Senses at Work

Students will learn about how organisms use their senses to live, grow, and respond to their environment.

1.3 Light and Sight

Students will focus on the sense of sight and what role light plays in vision. Students will relate sight and light to nocturnal animals in order to better understand the adaptations of bats.

1.4 Communication and Information Transfer

Students will learn how organisms communicate to transfer and share information.

Unit Project

Bat Chat

In this project, students will research bats to learn how their adaptations help them navigate and communicate, enabling them to find prey and avoid obstacles.

Unit Storyline

Students should be familiar with plant and animal adaptations from previous years of science study. While students may not be familiar with bats, they are introduced as a unique example of a nocturnal animal with a complex and interesting communication system.

In this unit, students will first learn about structural and behavioral adaptations and how these changes over time help a species survive. Students will consider how organisms receive and process different types of information through their senses. Students will focus their learning on one particular sense—vision—so that they can better understand how light plays an important role in seeing and sight. Students will investigate the reflective qualities of light as it relates to animals that are nocturnal. Last, students learn about how different organisms gather and transmit information to communicate. Students will extend the transfer of information to sound by researching how bats use patterns of sound to transmit and receive information.

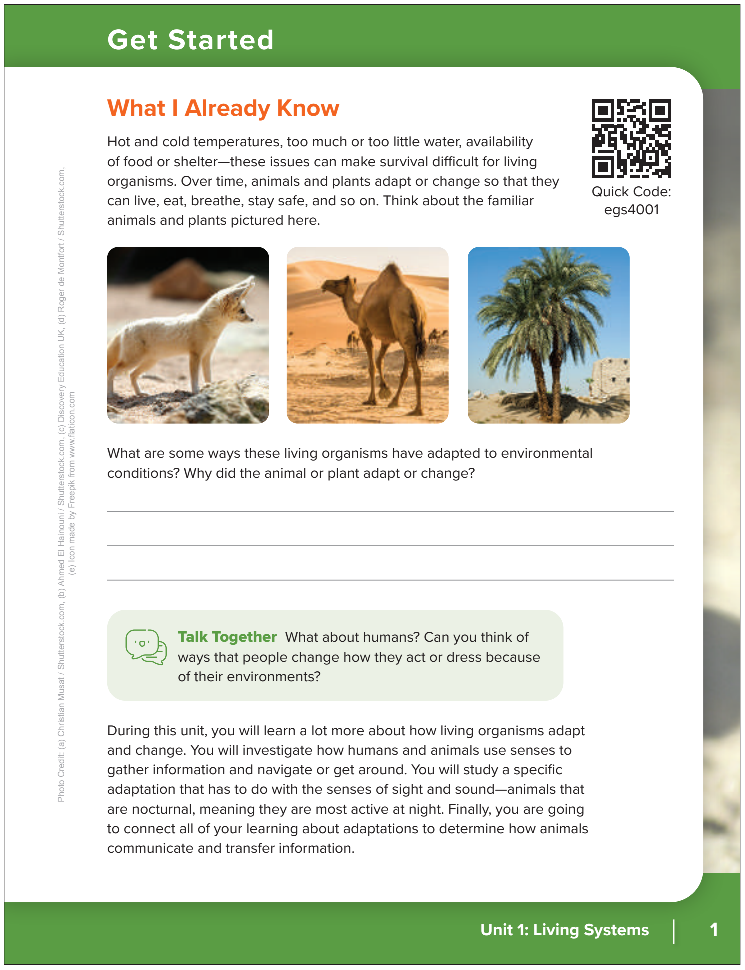
Unit 1 Introduction: Get Started

What I Already Know

Quick Code: egst4001

The Primary 4 Science curriculum starts each unit with an activity designed to activate students' prior knowledge. Unit 1 is focused on living systems, specifically on the ideas of adaptations, senses, and organism communication. Begin the unit by asking students to share what they have previously studied about animal and plant adaptations. Students should easily be able to discuss external features of animals and plants, such as feathers, fur, leaves/spines, and so on.

Students are asked to examine images of organisms that should be familiar from previous study of science and write about adaptations they can observe. Encourage students to think about and discuss why different organisms adapt or change over time. At this stage, fully formed or scientifically accurate answers are less important than motivating student interest and inquiry.


Get Started

What I Already Know

Hot and cold temperatures, too much or too little water, availability of food or shelter—these issues can make survival difficult for living organisms. Over time, animals and plants adapt or change so that they can live, eat, breathe, stay safe, and so on. Think about the familiar animals and plants pictured here.

Quick Code: egs4001

What are some ways these living organisms have adapted to environmental conditions? Why did the animal or plant adapt or change?

Talk Together What about humans? Can you think of ways that people change how they act or dress because of their environments?

During this unit, you will learn a lot more about how living organisms adapt and change. You will investigate how humans and animals use senses to gather information and navigate or get around. You will study a specific adaptation that has to do with the senses of sight and sound—animals that are nocturnal, meaning they are most active at night. Finally, you are going to connect all of your learning about adaptations to determine how animals communicate and transfer information.

Photo Credit: (a) Christian Musat / Shutterstock.com, (b) Ahmed El Hainouni / Shutterstock.com, (c) Discovery Education UK, (d) Roger de Montfort / Shutterstock.com, (e) Icon made by Freepik from www.flaticon.com

Unit 1: Living Systems | 1

Anchor Phenomenon: Studying Bats

While bats may be an unfamiliar organism for students, they have been chosen deliberately for the unit focus as they are both nocturnal (which represents both behavioral and structural adaptation) and have a sophisticated communication system that involves the senses of sight and sound. The Primary 4 Science curriculum uses the idea of an "anchor phenomenon" to connect all of the learning in a unit to a real-world example that students should find interesting and engaging. Bats and how they communicate and navigate at night are the anchor phenomenon for Unit 1.

Shift the class discussion from the familiar animals and plants in the What I Already Know activity to watch the video, study the image, and read the provided text for Studying Bats. Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Discuss the guiding questions with students, making the connection between the questions listed and the different concepts students will encounter in the unit.

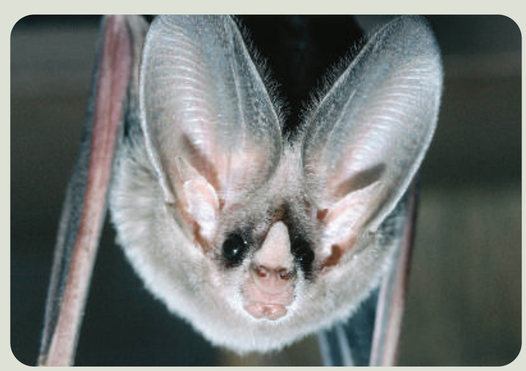
Studying Bats

Guiding Questions

- How do physical and behavioral adaptations of animals help them survive?
- How do senses help animals survive, grow and communicate?
- What role does light play in how humans and animals see?
- How do humans and other living organisms communicate?

Unit Project Preview

Bat Chat



Quick Code: egst4002

Introduce the idea of a unit project to students. Students should be familiar with project-based assessments from previous study in lower grades. The unit project will focus on how bats use specific adaptations to both survive and communicate. Encourage students to think of additional questions they have about bats before starting the first concept. You may wish to post these questions in the classroom as an ongoing reminder throughout the unit.

Question

How does communication among bats help them survive?

Photo Credit: (a) Pey Sun / Shutterstock.com, (b) Discovery Communications, Inc.

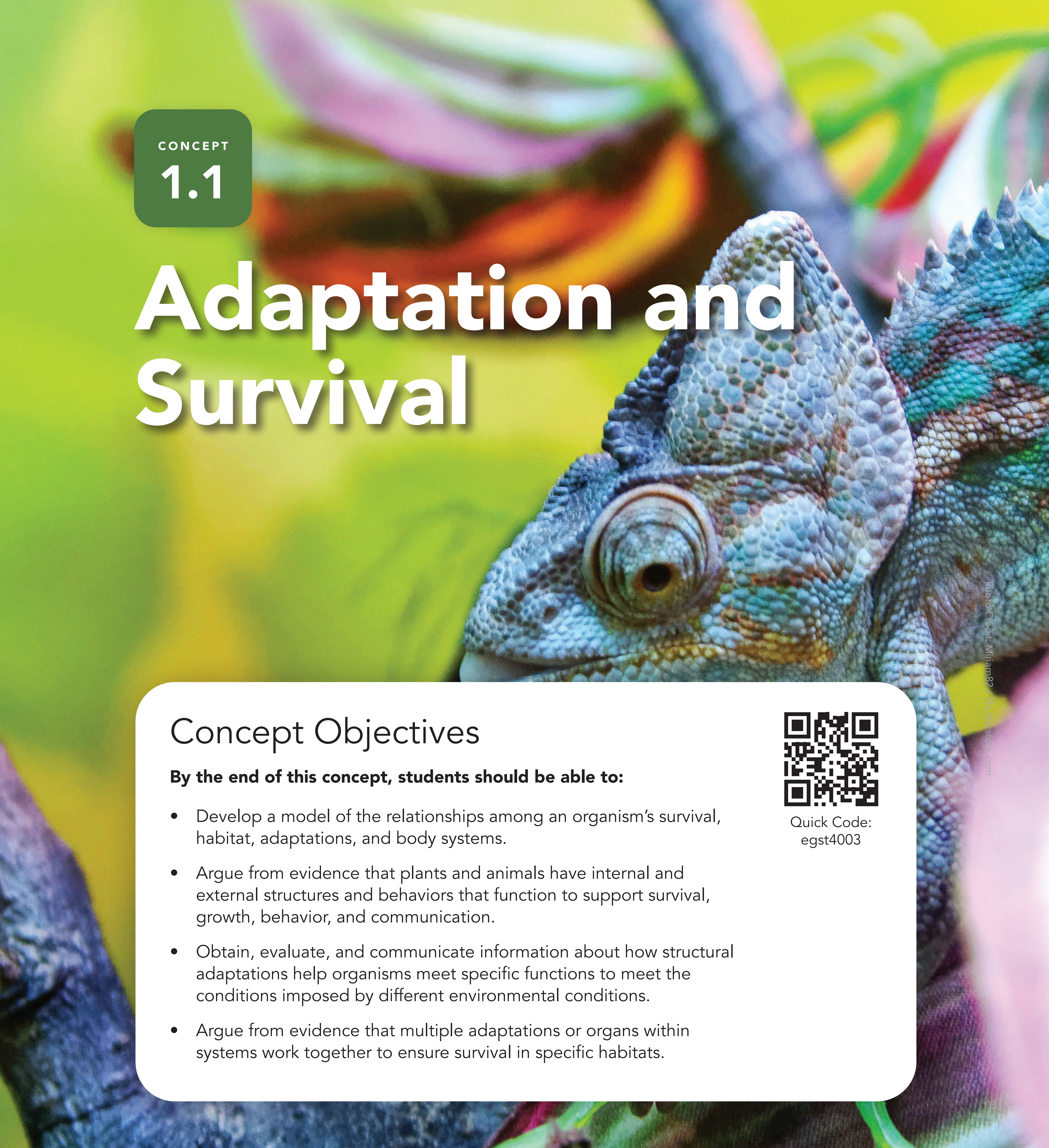


Photo Credit: Miriam82 / Shutterstock.com

CONCEPT

1.1

Adaptation and Survival

Concept Objectives

By the end of this concept, students should be able to:

- Develop a model of the relationships among an organism's survival, habitat, adaptations, and body systems.
- Argue from evidence that plants and animals have internal and external structures and behaviors that function to support survival, growth, behavior, and communication.
- Obtain, evaluate, and communicate information about how structural adaptations help organisms meet specific functions to meet the conditions imposed by different environmental conditions.
- Argue from evidence that multiple adaptations or organs within systems work together to ensure survival in specific habitats.

Quick Code:
egst4003

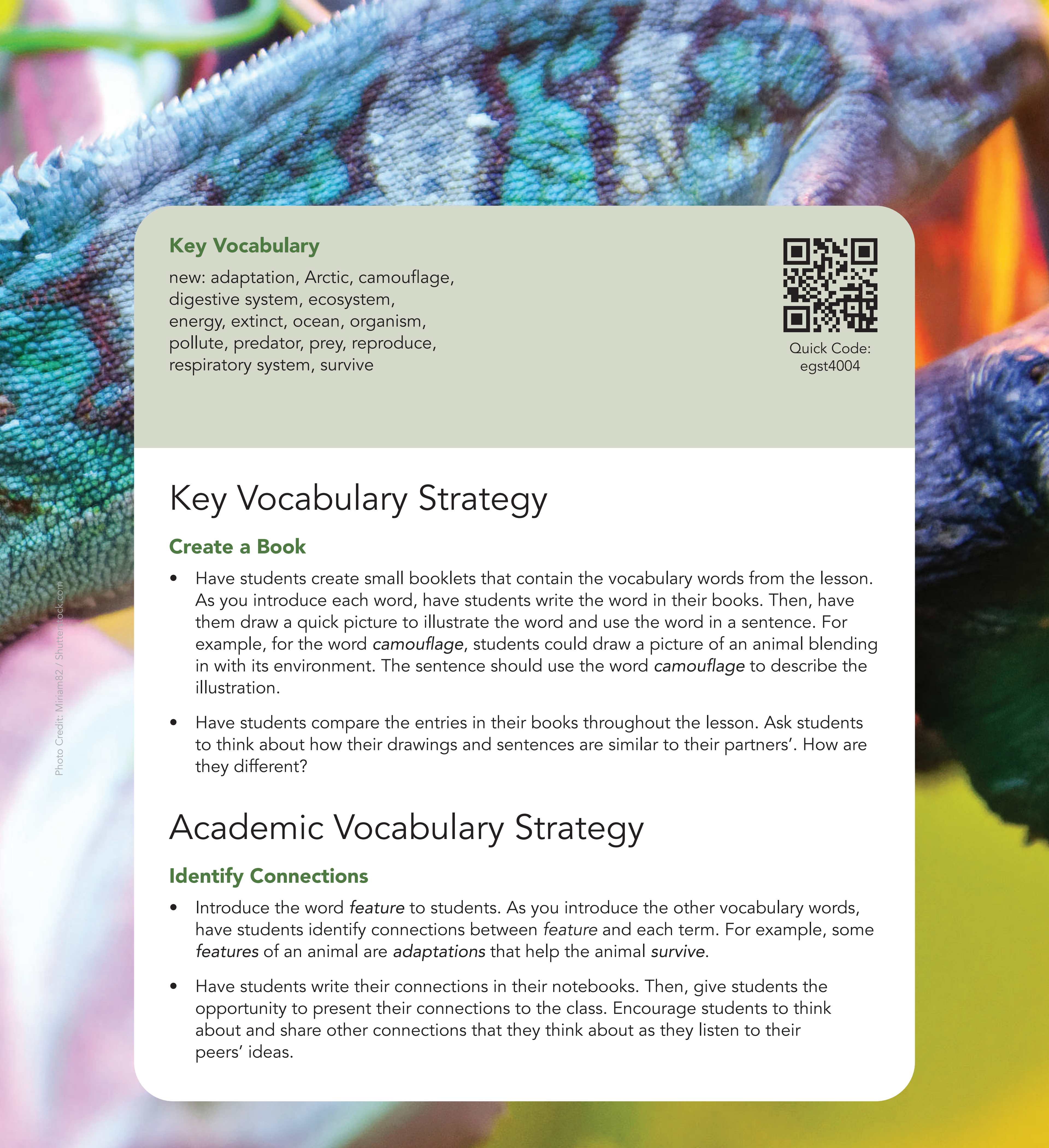


Photo Credit: Miriam82 / Shutterstock.com

Key Vocabulary

new: adaptation, Arctic, camouflage, digestive system, ecosystem, energy, extinct, ocean, organism, pollute, predator, prey, reproduce, respiratory system, survive

Quick Code:
egst4004

Key Vocabulary Strategy

Create a Book

- Have students create small booklets that contain the vocabulary words from the lesson. As you introduce each word, have students write the word in their books. Then, have them draw a quick picture to illustrate the word and use the word in a sentence. For example, for the word *camouflage*, students could draw a picture of an animal blending in with its environment. The sentence should use the word *camouflage* to describe the illustration.
- Have students compare the entries in their books throughout the lesson. Ask students to think about how their drawings and sentences are similar to their partners'. How are they different?

Academic Vocabulary Strategy

Identify Connections

- Introduce the word *feature* to students. As you introduce the other vocabulary words, have students identify connections between *feature* and each term. For example, some *features* of an animal are *adaptations* that help the animal *survive*.
- Have students write their connections in their notebooks. Then, give students the opportunity to present their connections to the class. Encourage students to think about and share other connections that they think about as they listen to their peers' ideas.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Get Started		Get Started	15 min
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	10 min
		Activity 3	10 min
Learn	Lesson 2	Activity 4	30 min
		Activity 5	15 min
	Lesson 3	Activity 6	15 min
		Activity 7	15 min
		Activity 8	15 min
	Lesson 4	Activity 9	15 min
		Activity 10	15 min
		Activity 11	15 min
	Lesson 5	Activity 12	20 min
		Activity 13	10 min
Share		Activity 14	15 min
	Lesson 6	Activity 15	25 min
		Activity 16	20 min

Content Background

Adaptations and Survival

Through the process of adaptation, species develop traits that make them better suited for survival in their environment. This process happens over many generations. For example, present-day giraffes have long necks that allow them to eat leaves from the tops of trees. Earlier giraffes did not have such long necks. Over many generations, the giraffe population shifted in the direction of the longer-necked trait because longer-necked individuals were more successful at surviving and reproducing. This type of adaptation is a structural adaptation.

Types of Adaptations

Throughout this concept, students learn about animals and plants that have adapted to living in extreme habitats. The organisms in polar and desert environments face survival challenges due to temperature changes, as well as, a lack of resources. Animals such as the Arctic fox and the penguins connect students with distant places that may have been previously unfamiliar to them.

There are two types of adaptations that can occur in organisms. Structural adaptations occur when the physical characteristics of an organism change for the organism to better survive in its environment. The other type of adaptation that can occur is a behavioral adaptation. Behavioral adaptations occur when there are changes in behavior to better survive. Examples of this type of adaptation include the seasonal migration of birds to warmer climates, as well as the use of hibernation as a strategy for survival during months without access to either food or water. Adaptation is important because it allows species to survive environmental changes. For example, if a climate becomes colder, over generations a species may develop traits such as thicker fur or a layer of fat. If a species cannot adapt to an environmental change over time, it is forced to move or else die out. For this reason, natural and human-made disasters that alter the environment more quickly than populations can adapt put entire species at risk.

Lesson 1

Activity 1
Can You Explain?

10 min

How do different types of animals and plants adapt to survive extreme climates?

Purpose

This activity draws on students' prior knowledge of adaptations by asking them to explain how animals adapt to extreme climates.

Instructional Focus

In this activity, students use prior knowledge to construct an explanation of how animals and plants use adaptations to survive extreme climates.

Life Skills **Endurance**

Strategy

Ask students to describe the local environment during summer. Encourage them to discuss the temperature, weather, and amount of sunlight. Then ask students to describe what they know about other environments in summer, such as the scene depicted in the image.

Students may have some initial ideas about how to answer the question. (See sample student response in the student edition page.) By the end of the concept, students should be able to construct a scientific explanation, which includes evidence from the concept activities.

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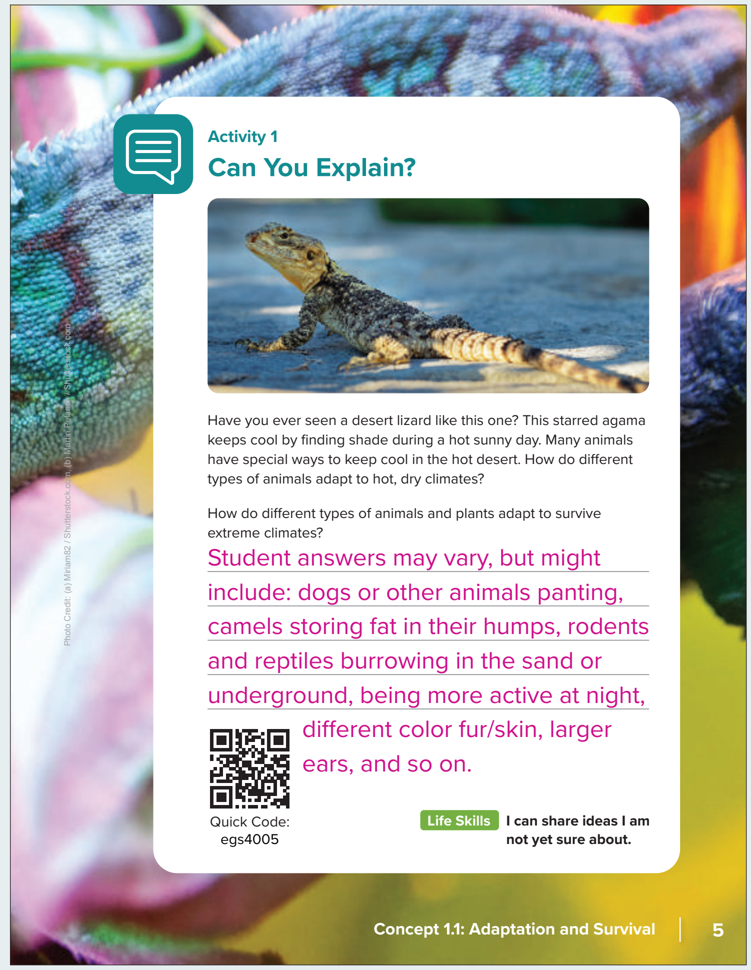


Activity 1

Can You Explain?

Have you ever seen a desert lizard like this one? This starred agama keeps cool by finding shade during a hot sunny day. Many animals have special ways to keep cool in the hot desert. How do different types of animals adapt to hot, dry climates?

How do different types of animals and plants adapt to survive extreme climates?

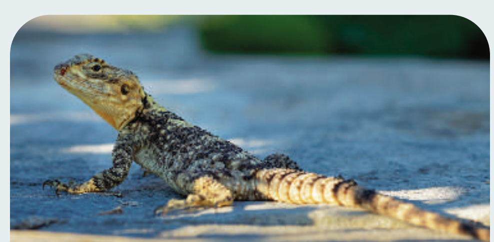
Student answers may vary, but might include: dogs or other animals panting, camels storing fat in their humps, rodents and reptiles burrowing in the sand or underground, being more active at night, different color fur/skin, larger ears, and so on.

Quick Code: egs4005

Life Skills I can share ideas I am not yet sure about.

Concept 1.1: Adaptation and Survival | 5

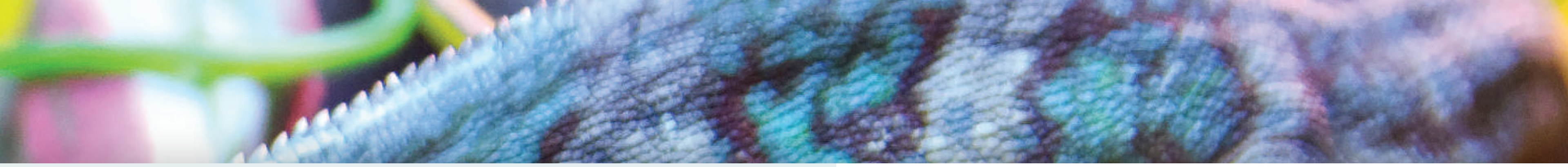
DIGITAL



Activity 1

Can You Explain?

Quick Code: egst4005



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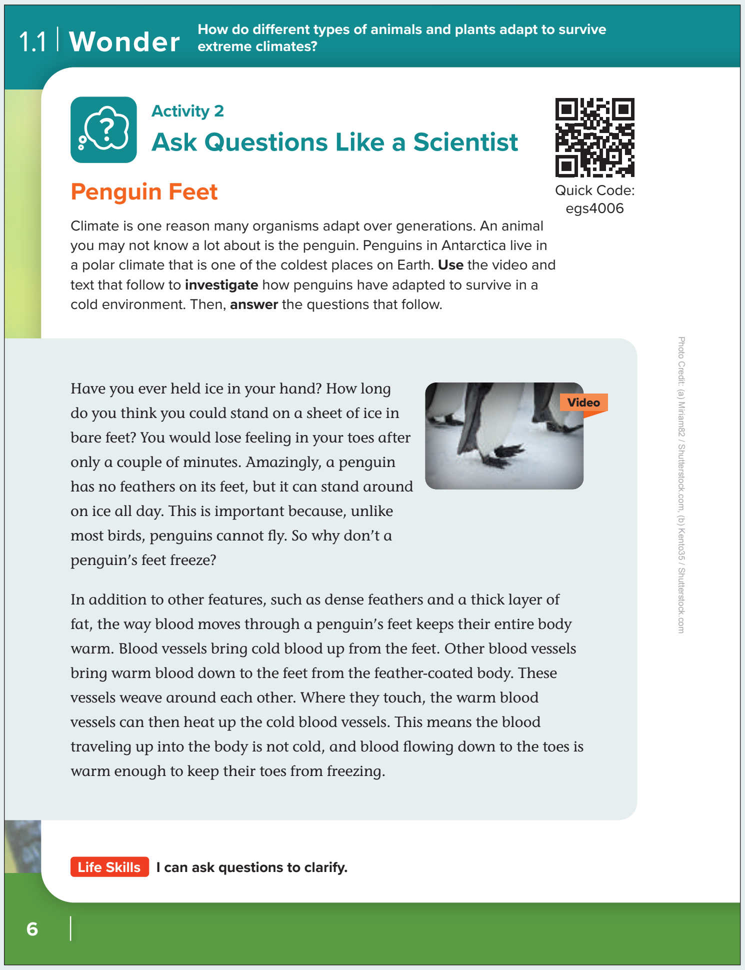

1.1 | Wonder **How do different types of animals and plants adapt to survive extreme climates?**

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4006

Penguin Feet

Climate is one reason many organisms adapt over generations. An animal you may not know a lot about is the penguin. Penguins in Antarctica live in a polar climate that is one of the coldest places on Earth. **Use** the video and text that follow to **investigate** how penguins have adapted to survive in a cold environment. Then, **answer** the questions that follow.

Have you ever held ice in your hand? How long do you think you could stand on a sheet of ice in bare feet? You would lose feeling in your toes after only a couple of minutes. Amazingly, a penguin has no feathers on its feet, but it can stand around on ice all day. This is important because, unlike most birds, penguins cannot fly. So why don't a penguin's feet freeze?

Video

In addition to other features, such as dense feathers and a thick layer of fat, the way blood moves through a penguin's feet keeps their entire body warm. Blood vessels bring cold blood up from the feet. Other blood vessels bring warm blood down to the feet from the feather-coated body. These vessels weave around each other. Where they touch, the warm blood vessels can then heat up the cold blood vessels. This means the blood traveling up into the body is not cold, and blood flowing down to the toes is warm enough to keep their toes from freezing.

Photo Credit: (a) Miriam82 / Shutterstock.com, (b) Kento35 / Shutterstock.com

Life Skills **I can ask questions to clarify.**

6

Photo Credit: Kento35 / Shutterstock.com

DIGITAL

Activity 2

Ask Questions Like a Scientist

Penguin Feet

Quick Code:
egst4006

Investigative Phenomenon

Activity 2

Ask Questions Like a Scientist

10 min

Penguin Feet

Purpose

The Investigative Phenomenon presents an engaging scenario—sometimes familiar and sometimes unfamiliar—to spark student curiosity about the world around them. This activity asks students to explore an adaptation to an extreme climate that might be unfamiliar: the polar regions.

Instructional Focus

In this activity, students gather information about and discuss how penguins' feet help them survive in the coldest places on Earth. Students develop questions about adaptations for further investigation throughout the concept.

Life Skills **Negotiation**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

After considering the hot, dry climate of the desert lizard, students now turn to explore the opposite extreme: the icy cold polar regions. Ask students to share what they already know about polar climates. Since these regions are unfamiliar to most students around the world, encourage them to imagine what extreme cold might feel like and share any personal experience with cold temperatures or objects.

Lesson 1, *continued*

Ask students if they have ever walked on a cold floor with their bare feet. Where did this happen? What was their response?

Use the text and video about how penguin feet are uniquely suited for survival in a cold environment to initiate student thinking about animal adaptations and traits.

ASK *Why do penguins' feet not freeze when they live and walk in such cold climates?*

Have students come up with a list of questions they have about penguins or other animals that live in cold environments.

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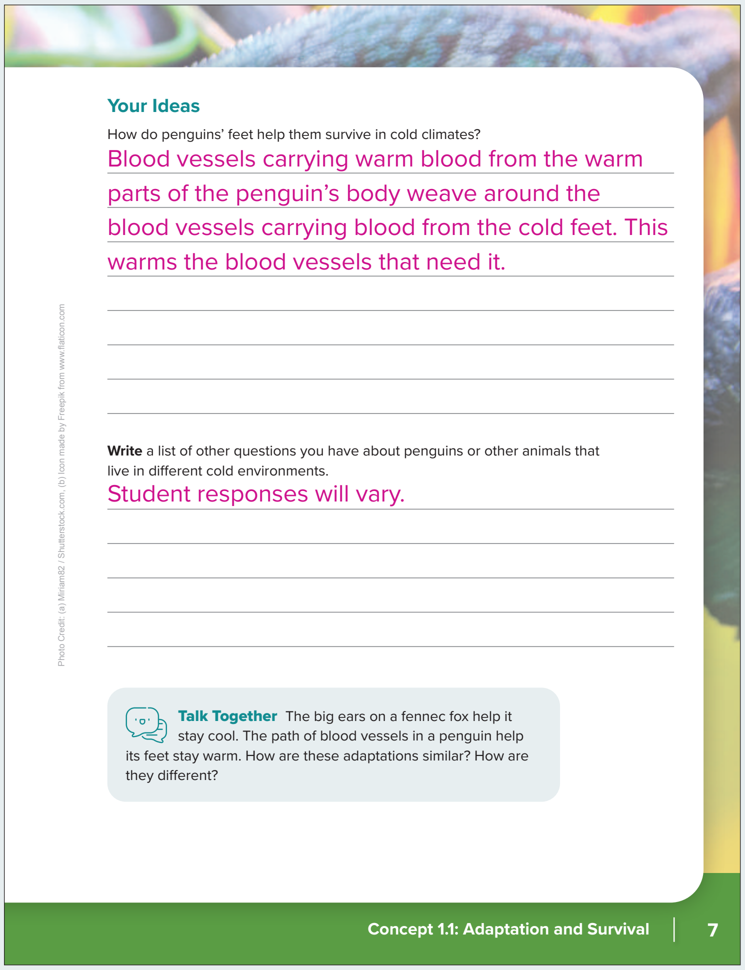
Page 7



Your Ideas

How do penguins' feet help them survive in cold climates?

Blood vessels carrying warm blood from the warm parts of the penguin's body weave around the blood vessels carrying blood from the cold feet. This warms the blood vessels that need it.

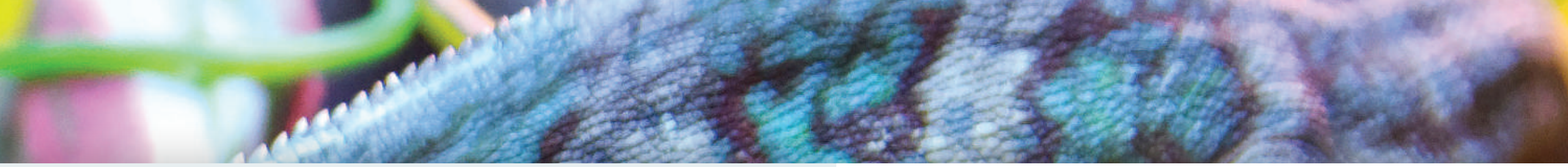
Write a list of other questions you have about penguins or other animals that live in different cold environments.

Student responses will vary.

Talk Together The big ears on a fennec fox help it stay cool. The path of blood vessels in a penguin help its feet stay warm. How are these adaptations similar? How are they different?

Photo Credit: (a) Miriam82 / Shutterstock.com, (b) Icon made by Freepik from www.flaticon.com

Concept 1.1: Adaptation and Survival | 7



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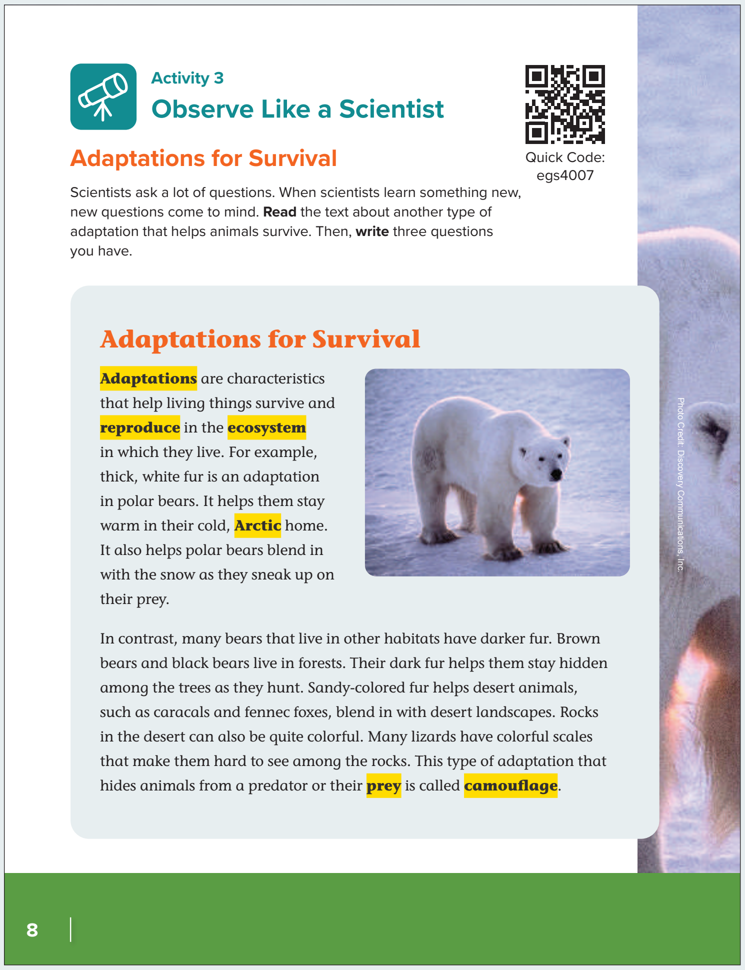
Page 8



Activity 3

Observe Like a Scientist

Adaptations for Survival

Quick Code: egs4007

Scientists ask a lot of questions. When scientists learn something new, new questions come to mind. **Read** the text about another type of adaptation that helps animals survive. Then, **write** three questions you have.

Adaptations for Survival

Adaptations are characteristics that help living things survive and **reproduce** in the **ecosystem** in which they live. For example, thick, white fur is an adaptation in polar bears. It helps them stay warm in their cold, **Arctic** home. It also helps polar bears blend in with the snow as they sneak up on their prey.

In contrast, many bears that live in other habitats have darker fur. Brown bears and black bears live in forests. Their dark fur helps them stay hidden among the trees as they hunt. Sandy-colored fur helps desert animals, such as caracals and fennec foxes, blend in with desert landscapes. Rocks in the desert can also be quite colorful. Many lizards have colorful scales that make them hard to see among the rocks. This type of adaptation that hides animals from a predator or their **prey** is called **camouflage**.

Photo Credit: Discovery Communications, Inc.

8

DIGITAL

Activity 3

Observe Like a Scientist

Adaptations for Survival

Quick Code: egst4007

Lesson 1, *continued*

Activity 3
Observe Like a Scientist

10 min

Adaptations for Survival

Purpose

In this activity, students are encouraged to ask questions like scientists. The text introduces contrasting adaptations in similar animals that live in different environments to emphasize that adaptations occur in response to the environment over many generations.

Instructional Focus

In this activity, students read an informational text and develop questions about the relationships between an organism's environment, adaptations, and survival.

Strategy

Provide students with an example of a time when learning something new prompted more questions. For example, learning about how a penguin's feet stay warm might prompt the questions: *How does a penguin's head stay warm without thick fur? Do other animals have similarly wrapped blood vessels?*

Instruct students to read the text about adaptations either independently or in pairs for literacy support. Review the familiar vocabulary words adaptation and ecosystem with the whole class as needed.

Lesson 1, *continued*

As they read, encourage students to think of more questions that they have related to the relationships between an animal's environment, adaptations, and survival. Direct students to record their questions in the chart provided. Return to these questions periodically to record developing answers and more questions to support students' skill of asking questions.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- Would I organize this differently next year?

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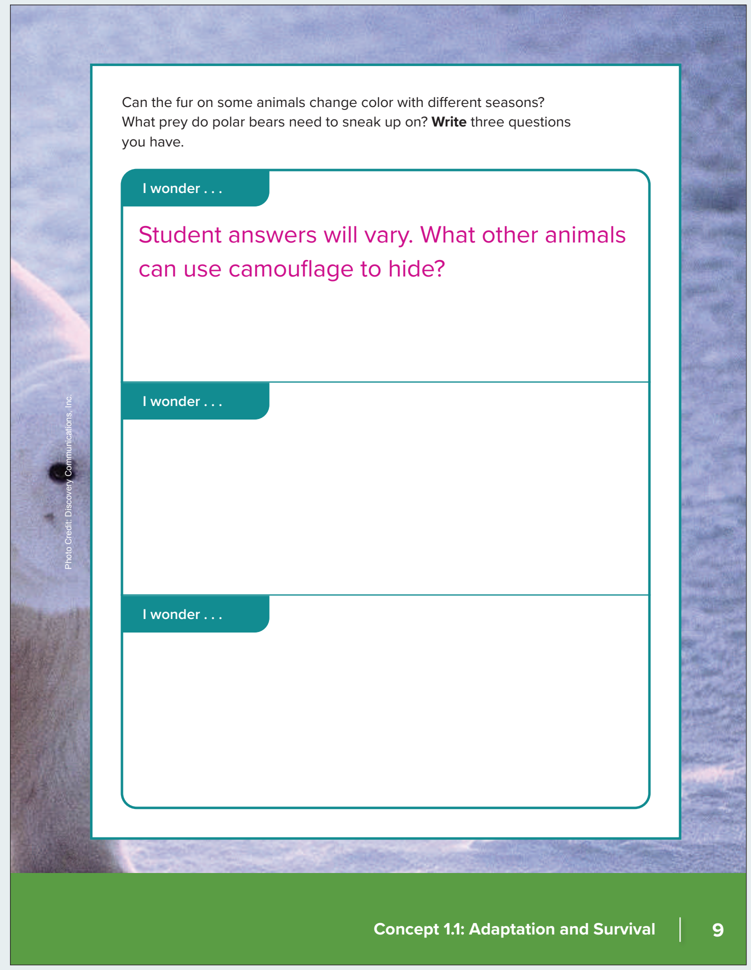
Page 9



Can the fur on some animals change color with different seasons? What prey do polar bears need to sneak up on? **Write** three questions you have.

I wonder . . .

Student answers will vary. What other animals can use camouflage to hide?

I wonder . . .

I wonder . . .

Photo Credit: Discovery Communications, Inc.

Concept 1.1: Adaptation and Survival | 9

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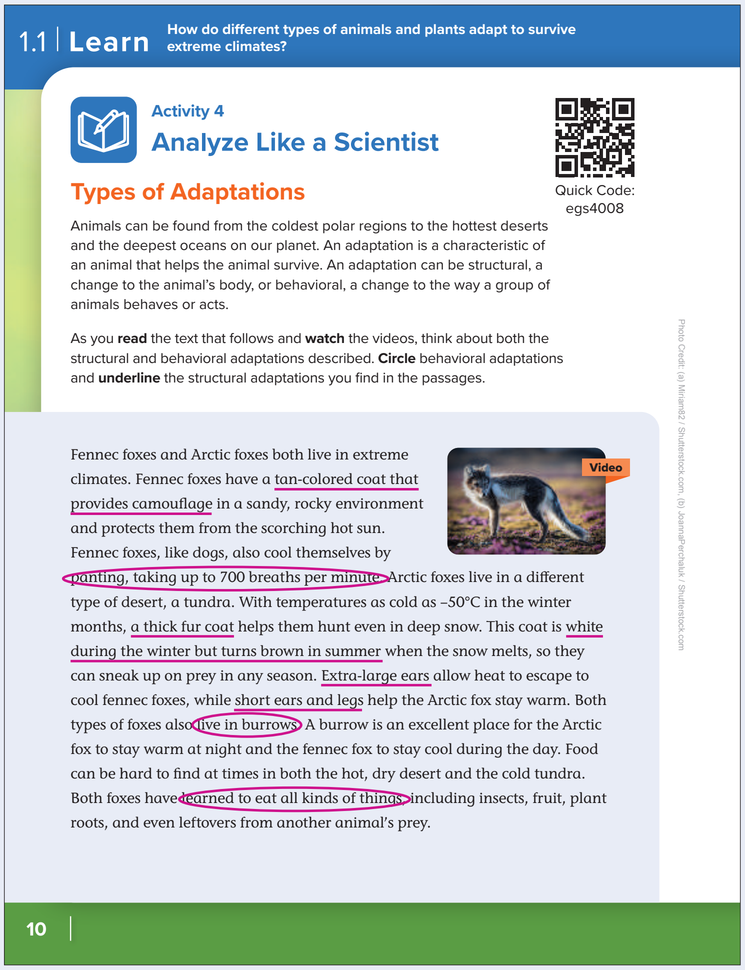
Page 10


1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

Activity 4

Analyze Like a Scientist

Quick Code: egs4008

Types of Adaptations

Animals can be found from the coldest polar regions to the hottest deserts and the deepest oceans on our planet. An adaptation is a characteristic of an animal that helps the animal survive. An adaptation can be structural, a change to the animal's body, or behavioral, a change to the way a group of animals behaves or acts.

As you **read** the text that follows and **watch** the videos, think about both the structural and behavioral adaptations described. **Circle** behavioral adaptations and **underline** the structural adaptations you find in the passages.

Video

Fennec foxes and Arctic foxes both live in extreme climates. Fennec foxes have a tan-colored coat that provides camouflage in a sandy, rocky environment and protects them from the scorching hot sun. Fennec foxes, like dogs, also cool themselves by panting, taking up to 700 breaths per minute. Arctic foxes live in a different type of desert, a tundra. With temperatures as cold as –50°C in the winter months, a thick fur coat helps them hunt even in deep snow. This coat is white during the winter but turns brown in summer when the snow melts, so they can sneak up on prey in any season. Extra-large ears allow heat to escape to cool fennec foxes, while short ears and legs help the Arctic fox stay warm. Both types of foxes also live in burrows. A burrow is an excellent place for the Arctic fox to stay warm at night and the fennec fox to stay cool during the day. Food can be hard to find at times in both the hot, dry desert and the cold tundra. Both foxes have learned to eat all kinds of things, including insects, fruit, plant roots, and even leftovers from another animal's prey.

Photo Credit: (a) Miriam82 / Shutterstock.com, (b) JoannaPerchaluk / Shutterstock.com

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Photo Credit: JoannaPerchaluk / Shutterstock.com

DIGITAL

Activity 4

Analyze Like a Scientist

Types of Adaptations

Quick Code: egst4008

Lesson 2

Activity 4 Analyze Like a Scientist

30 min

Types of Adaptations

Purpose

This activity introduces students to two different types of adaptations: structural and behavioral. Students explore how adaptations in three animals help them live in extreme climates.

Instructional Focus

In this activity, students record evidence of behavioral and structural adaptations in animals that live in extreme environments.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before reading the text, ask students to recall of some of the adaptations they have already learned about in this concept.

ASK

- *How does having an adaptation help animals to survive?*
  Student answers will vary. At this point in the concept, students might only consider physical features to be adaptations.
- *Can an adaptation ever be something that is not a body feature?*
  Yes, there are some behaviors that help an animal to survive.

Lesson 2, *continued*

ASK

- *Some animals migrate (travel long distances) at certain times of the year. Is this a physical adaptation or would you call this something different?*
  Guide students toward the understanding that migration is not a physical adaptation but a behavior that can help animals survive. Some physical adaptations support this activity, but the act of migrating is a behavior.

Assign students the text passage within Types of Adaptations. As students read, they should identify behavioral and structural adaptations in the three animals profiled. After gathering information, as directed in the student instructions, students should complete the graphic organizer based on their findings.

Then, if possible, show students the videos as a class or in small groups. Ask students to look for additional physical structures and behaviors that help the animals survive.

Use the text and videos to get students thinking about the two different types of adaptations. If time allows, form pairs or small groups. Encourage students to discuss the concept of adaptations in the context of their findings from the text and videos. As students discuss, circulate among them, listening for questions and disagreements to share with the class.

Give pairs/groups time to discuss the validity of their ideas before sharing them with the class.

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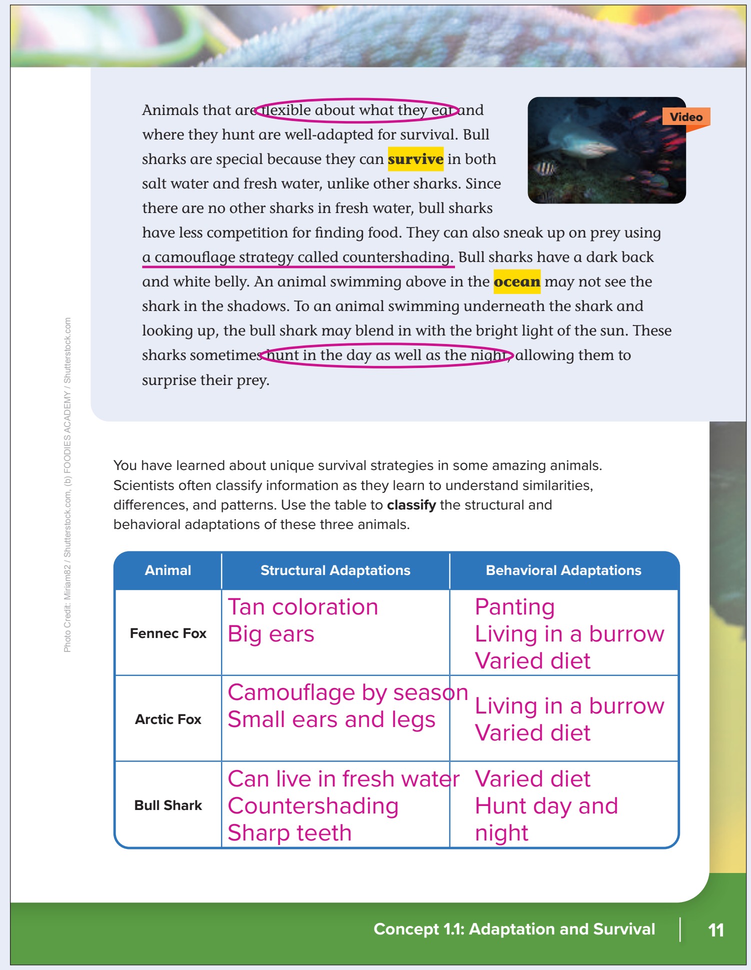

Animals that are flexible about what they eat and where they hunt are well-adapted for survival. Bull sharks are special because they can **survive** in both salt water and fresh water, unlike other sharks. Since there are no other sharks in fresh water, bull sharks have less competition for finding food. They can also sneak up on prey using a camouflage strategy called countershading. Bull sharks have a dark back and white belly. An animal swimming above in the **ocean** may not see the shark in the shadows. To an animal swimming underneath the shark and looking up, the bull shark may blend in with the bright light of the sun. These sharks sometimes hunt in the day as well as the night, allowing them to surprise their prey.

Video

You have learned about unique survival strategies in some amazing animals. Scientists often classify information as they learn to understand similarities, differences, and patterns. Use the table to **classify** the structural and behavioral adaptations of these three animals.

Animal	Structural Adaptations	Behavioral Adaptations
Fennec Fox	Tan coloration Big ears	Panting Living in a burrow Varied diet
Arctic Fox	Camouflage by season Small ears and legs	Living in a burrow Varied diet
Bull Shark	Can live in fresh water Countershading Sharp teeth	Varied diet Hunt day and night

Photo Credit: Miriam82 / Shutterstock.com, (b) FOODIES ACADEMY / Shutterstock.com

Concept 1.1: Adaptation and Survival | 11

Pathways to Learning

Print	Ask students to read the text passage within Types of Adaptations and record their findings according to the student directions. After reading, students should complete the graphic organizer.
Blended	Ask students to read the text passage within Types of Adaptations and record their findings according to the student directions. After reading, students should complete the graphic organizer. Show the students the videos either as a class or in small groups.
Digital	Either as a class or in small groups, watch the videos. Ask students to complete the graphic organizer online.

Lesson 2, *continued*

What Are Some Examples of Adaptations in Animals and Plants?

Activity 5
Observe Like a Scientist

15 min

The Panther Chameleon

Purpose

In this activity, students investigate a lizard with adaptations suited for life in the rainforest. Learning about the panther chameleon provides students with a contrasting example to the desert lizard introduced earlier in the concept, the starred agama. Students use what they have learned about different types of adaptations to look for examples of survival strategies specific to this animal.

Instructional Focus

In this activity, students construct explanations about how different types of adaptations help the panther chameleon survive.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

- Ask students to read The Panther Chameleon.
- Then, if possible, show students the video as a whole class or in small groups.

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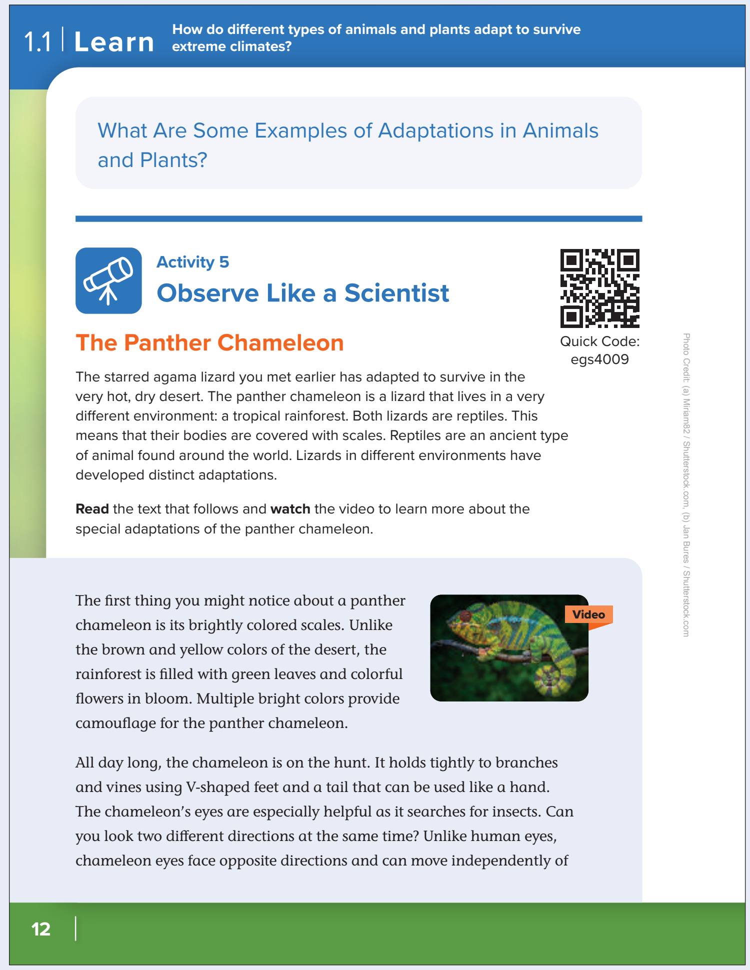

1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

What Are Some Examples of Adaptations in Animals and Plants?

Activity 5

Observe Like a Scientist

Quick Code: egs4009

The Panther Chameleon

The starred agama lizard you met earlier has adapted to survive in the very hot, dry desert. The panther chameleon is a lizard that lives in a very different environment: a tropical rainforest. Both lizards are reptiles. This means that their bodies are covered with scales. Reptiles are an ancient type of animal found around the world. Lizards in different environments have developed distinct adaptations.

Read the text that follows and **watch** the video to learn more about the special adaptations of the panther chameleon.

The first thing you might notice about a panther chameleon is its brightly colored scales. Unlike the brown and yellow colors of the desert, the rainforest is filled with green leaves and colorful flowers in bloom. Multiple bright colors provide camouflage for the panther chameleon.

Video

All day long, the chameleon is on the hunt. It holds tightly to branches and vines using V-shaped feet and a tail that can be used like a hand. The chameleon's eyes are especially helpful as it searches for insects. Can you look two different directions at the same time? Unlike human eyes, chameleon eyes face opposite directions and can move independently of

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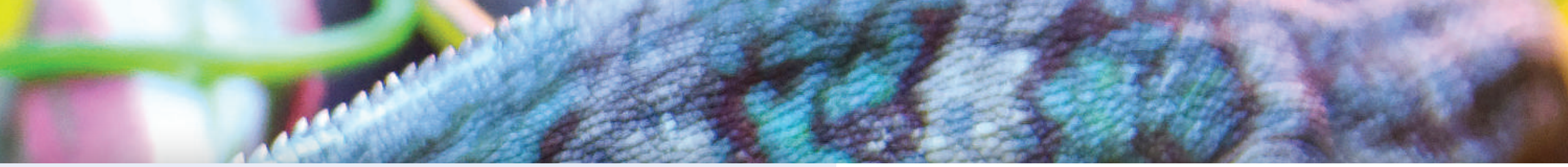
Activity 5
Observe Like a Scientist
The Panther Chameleon

Quick Code:
egst4009

Photo Credit: Jan Bures / Shutterstock.com



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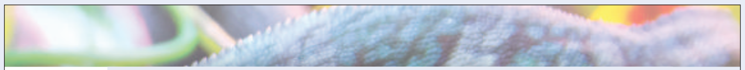

each other. One eye can be searching for something to eat, while the other is on the lookout for danger in a totally different direction. This adaptation allows the panther chameleon to both find a meal and avoid becoming one at the same time.

If the chameleon does find itself in danger, however, it has one last trick. Since this lizard does not have teeth or claws for defense, it tries to make itself look fierce. First, it puffs up its body with air. Then, it opens its mouth wide. It can also change the colors of its scales. This display will probably scare the attacker.

How is the panther chameleon well-adapted for survival in the rainforest? In the chart, **record** the adaptations described in the passage. Then, **classify** each as structural or behavioral. **Describe** how each adaptation helps the chameleon survive.

Data Table: Evidence of Adaptations in Living Things

Adaptation	Structural (S) or Behavioral (B)	How does the adaptation help the animal?
Vivid colors	S	Camouflage to hunt and hide
V-shaped feet	S	Balance and move
Eyes that move in different directions	S	Hunt
Puffing body up/ opening mouth	B	Scare attackers
Changing colors	B	Defend or survive

Concept 1.1: Adaptation and Survival | 13

Lesson 2, *continued*

- Next, direct students to complete the table, Evidence of Adaptations in Living Things.
- Finally, place students in pairs or small groups. Prompt students to discuss the evidence from their data table, defending their reasoning about how they classified different adaptations.
- As students discuss, encourage students to add to, or revise, their charts as they discuss with their peers.

Lesson 3

Activity 6
Analyze Like a Scientist

15 min

Plant Adaptations

Purpose

This activity introduces students to trees that are well-adapted to surviving the challenges of two different habitats, both with extreme climates. Students are asked to consider whether plants can have behavioral adaptations and then examine a text for evidence.

Instructional Focus

In this activity, students gather evidence and discuss adaptations of the acacia tree and the kapok tree.

Strategy

In this activity, students begin to consider whether plants can have behavioral and structural adaptations.

Prior to reading Two Terrific Trees, remind students of the two lizards that they have learned about from different ecosystems. Ask students to recall that these two animals have different structural and behavioral adaptations that allow them to survive in their own environments.

ASK

- *Can plants have behavior or develop behavioral adaptations?*
  Student answers will vary. Some students may have experience with plants that have turned to grow toward a window or other light source. Students may also have some familiarity with plants such as the Venus flytrap that have behavioral adaptations for catching prey.

Prompt students to read Two Terrific Trees with a partner.

After reading, provide time for students to discuss the adaptations of both trees. Ask students to share with the class whether their opinion about behavioral adaptations in plants has changed, using evidence from the text to support their stance.

PRINT

Pages 14-15


Activity 6
Analyze Like a Scientist

Plant Adaptations

Quick Code:
egs4010

You can find plants growing in almost every place that sunlight shines. Even the bottom of sea ice in polar regions has tiny plants growing on it. Like animals, plants have structural adaptations that help them survive and grow in different environments. Can plants also have behavioral adaptations? **Read** the passage that follows to find out.

Two Terrific Trees

Surviving on the Southern African savannah can be tough for many plants. The temperature in this grassland habitat is mild, but the lack of water is extreme. During the dry season, which lasts for half of the year, almost no rain falls. Due to these drought conditions, most large plants cannot grow here. If you stand on a hill and look over the savannah though, there is one large tree that can be seen scattered throughout the landscape.

This is an acacia tree. The acacia is built to survive through many months of drought. Tiny leaves growing on the top of this "umbrella" tree help hold in water while soaking up sunlight needed to make food. One very long root, a taproot, grows downward. This root searches for water as deep as 35 meters below the surface. Like a camel storing fat in its hump, the acacia tree stores water in its trunk.

Umbrella Acacia

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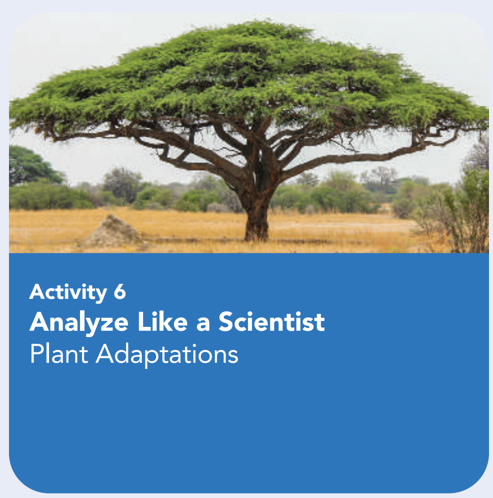

Quick Code:
egst4010

Photo Credit: LuminatePhotos by judith / Shutterstock.com

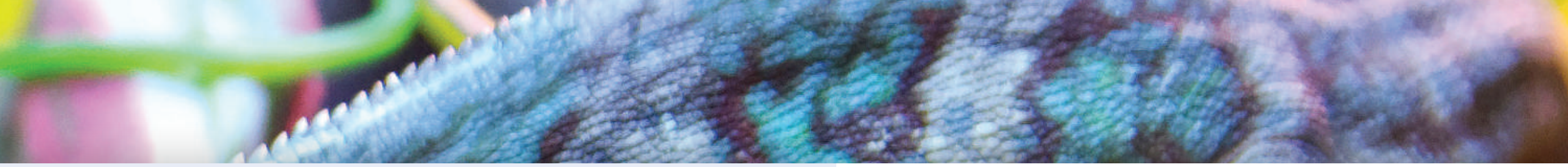

Photo Credit: Vasilyev Alexandr / Shutterstock.com

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Page 16

1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

Activity 7

Think Like a Scientist

Plant Scientist

Quick Code: egs4011

In this investigation, you will carry out the work of plant scientists, called botanists. You have just learned about how the roots, trunks, and leaves of two trees have adapted to extremely different environments. Consider what you know about how each part of a plant plays a role in getting the plant what it needs to survive.

What Will You Do?

Examine the photos for clues that might tell a story about the conditions and environment where these plants live. Which adaptations do you think are critical to their survival? **Record** your answers in the table.

Palm Tree in a Desert

Pine Trees in the Snow

Mangrove Trees in Saltwater

Water Lilies in a Wetland

Acacia Trees on the Savannah

Barbary Fig in a Desert

Life Skills I can analyze a situation.

Photo Credit: (a) Miriam82 / Shutterstock.com, (b) pixinoo / Shutterstock.com, (c) Mikadun / Shutterstock.com, (d-f) Paul Fuqua, (g) Discovery Communications, Inc.

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DIGITAL

Activity 7
Think Like a Scientist
Plant Scientist

Quick Code:
egst4011

Lesson 3, *continued*

Activity 7

Think Like a Scientist

15 min

Plant Scientist

Purpose

In this activity, students apply what they know about the parts of a plant and structural and behavioral adaptations to a close observation of images to look for evidence for adaptations.

Instructional Focus

In this activity, students collect data on plants in specific environments and use that data as evidence to argue that those plants may have adapted to their environment over time.

Life Skills **Decision-Making**

Activity Activator

In this investigation, students will collect data on the environments and plants observed in each picture, identify the characteristics of the plants that affect how they survive, and analyze any special features of each plant to explain how each plant has specific characteristics that help it survive.

If possible, print out one or two full-page copies of each image (accessible online) and facilitate this investigation in stations as described below. If printing or stations are not feasible, the images are provided in student books and the investigation can be conducted in pairs or small groups.

Lesson 3, *continued*

Before class, set up a station for each plant picture in different parts of the room. Label each plant using an index card. To introduce the activity, ask students to describe each plant's natural environment. Students should know that cacti are found in deserts, which are generally hot and dry. Students should also know that lotuses (water lilies) are found in freshwater environments, such as ponds or rivers. Record the environments and their characteristics on the board and display them throughout the activity. Then, instruct students to observe each plant and identify traits that they think help it survive in its particular environment.

Activity Procedure: What Will You Do?

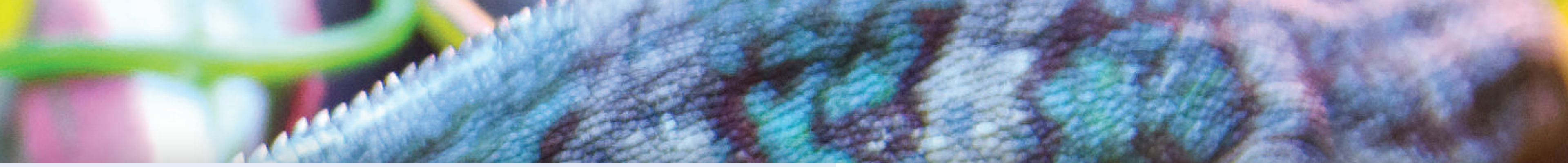
Part 1: Set Up the Stations

Prepare pictures of 5–10 plants.

1. Print each picture on an individual piece of cardstock. The pictures can be found in the online Teacher Guide for this activity.
2. Prepare the index cards by writing the name of the environment where each chosen plant lives.
3. Place each plant picture and the corresponding environment index card at one of the stations around the classroom.

Materials List (per group)

- Pictures of plants in different environments
- Index cards
- Markers



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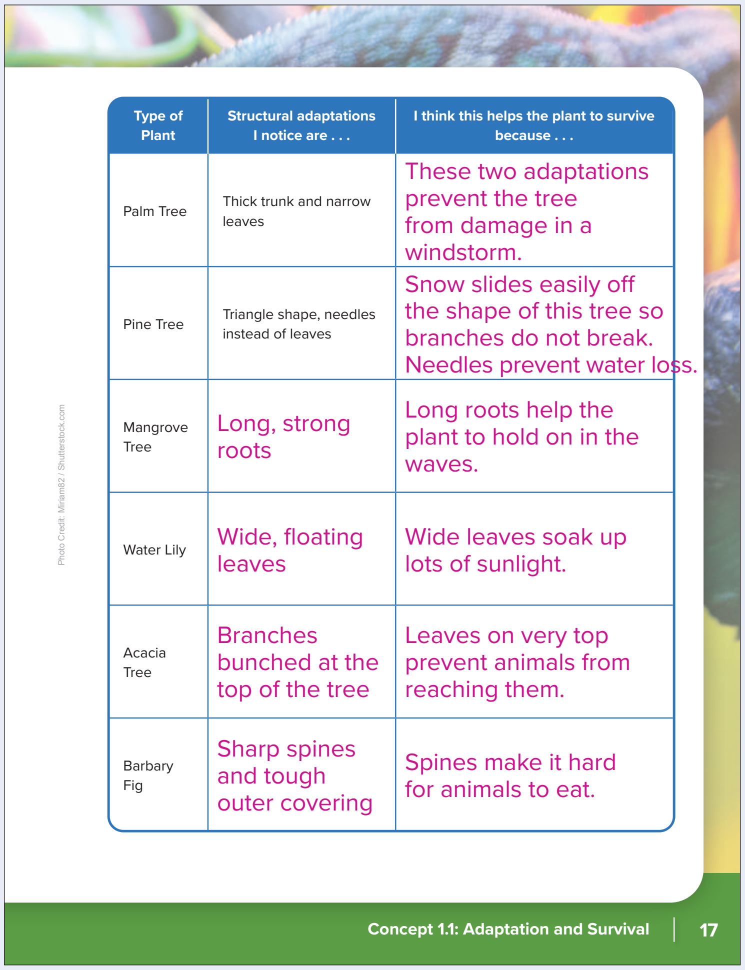

Type of Plant	Structural adaptations I notice are . . .	I think this helps the plant to survive because . . .
Palm Tree	Thick trunk and narrow leaves	These two adaptations prevent the tree from damage in a windstorm.
Pine Tree	Triangle shape, needles instead of leaves	Snow slides easily off the shape of this tree so branches do not break. Needles prevent water loss.
Mangrove Tree	Long, strong roots	Long roots help the plant to hold on in the waves.
Water Lily	Wide, floating leaves	Wide leaves soak up lots of sunlight.
Acacia Tree	Branches bunched at the top of the tree	Leaves on very top prevent animals from reaching them.
Barbary Fig	Sharp spines and tough outer covering	Spines make it hard for animals to eat.

Photo Credit: Miriam82 / Shutterstock.com

Concept 1.1: Adaptation and Survival | 17

Lesson 3, *continued*

Part 2: Introduce the Stations

1. Show students where each station is located.
2. You may want students to recall information about each environment. Have students describe characteristics of each environment, such as the weather, types of animals, and the type of soil found for each area.
3. Summarize information on environments on the board where students can refer to this information throughout the investigation.

Lesson 3, *continued*

Part 3: Student Investigation

Divide students into small groups. Have students observe each picture to identify how the structures may differ among plants based on their environment. Students discuss how the structural adaptations they observe help the plants survive.

Students should record their observations in the table. Students have been provided with examples of structural adaptations for the pine and palm trees. Sample answers are only given to provide some possible examples of student responses. All reasonable responses should be accepted.

Possible topics for groups to discuss:

- How far the plants' roots spread out
- How the plants' leaves look
- How much sun the plant needs, or how it gets the sunlight
- The shape of the plants' leaves
- How the plant reproduces
- Types of defense mechanisms the plant has, such as thorns
- How the plant takes in nutrients

Teacher Reflection

- Can my students identify various structural and behavioral adaptations?
- What data did my students struggle with during the hands-on investigations and observe activities?
- What other examples of structural and behavioral adaptations could I include the next time I teach this lesson?

PRINT

Page 18

1.1 | **Learn** How do different types of animals and plants adapt to survive extreme climates?

Think About the Activity

What are some characteristics of plants that help them survive?

Answers will vary. Students should note that plants have different shaped leaves and various root systems to help them survive.

Compare and contrast adaptations of plants to their environments. How are they the same? How are they different?

Answers will vary. Students should note that the roots, leaves, and stems are common parts of a plant that may be different based on adaptations to the environment. Adaptation can affect the size, shape, and design of these features.

What would happen if a plant were placed in a different environment?

Answers will vary. Students should note the plant would struggle to meet its needs and may not survive.

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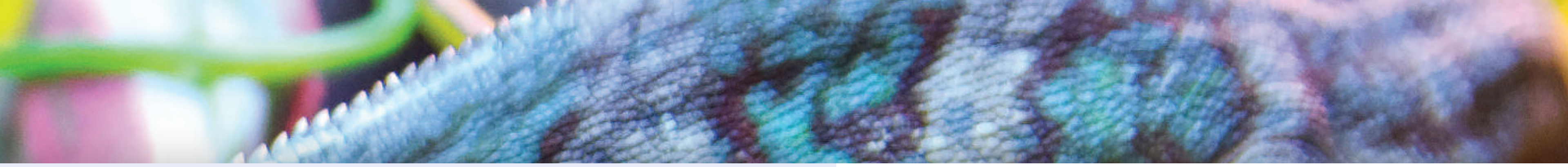

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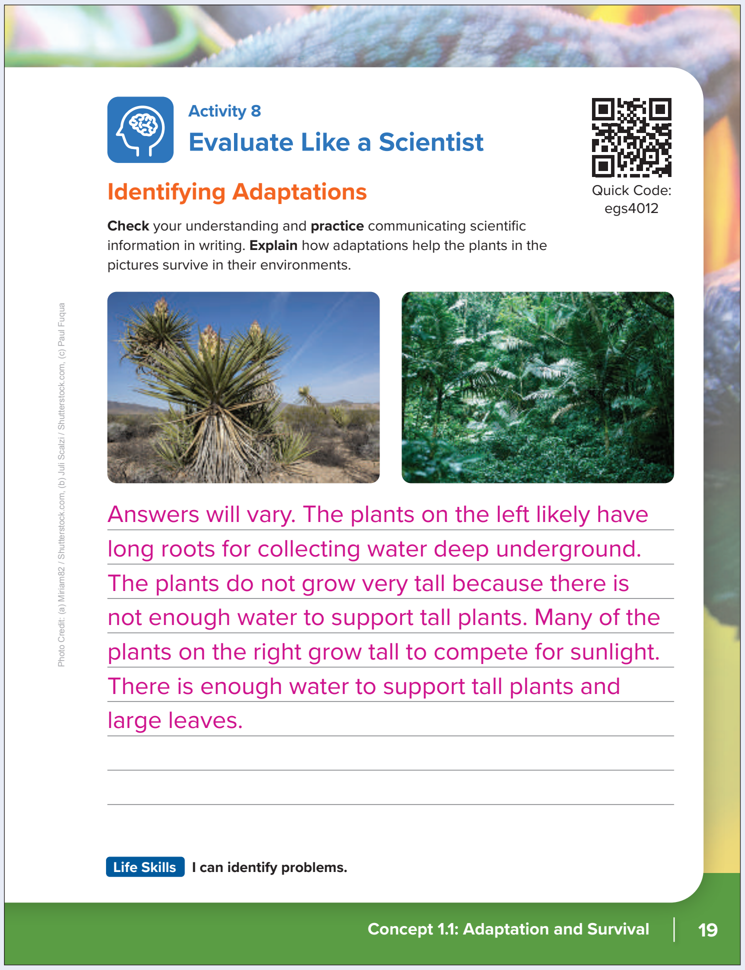

Activity 8

Evaluate Like a Scientist

Identifying Adaptations

Quick Code: egs4012

Check your understanding and **practice** communicating scientific information in writing. **Explain** how adaptations help the plants in the pictures survive in their environments.

Answers will vary. The plants on the left likely have long roots for collecting water deep underground. The plants do not grow very tall because there is not enough water to support tall plants. Many of the plants on the right grow tall to compete for sunlight. There is enough water to support tall plants and large leaves.

Life Skills I can identify problems.

Concept 1.1: Adaptation and Survival | 19

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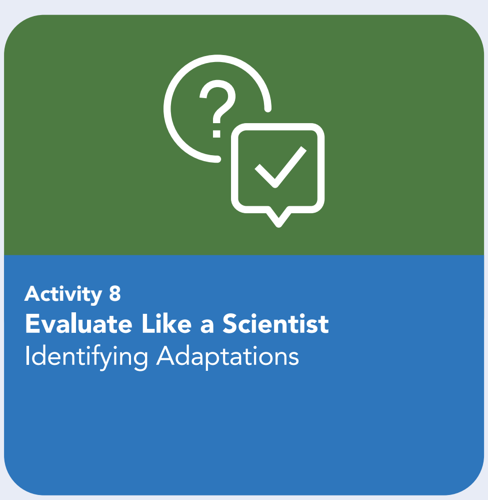

Quick Code:
egst4012

Activity 8

Evaluate Like a Scientist

15 min

Identifying Adaptations

Purpose

In this activity, students reflect upon and share what they have learned about how plants have adaptations to survive in specific environments. Students apply their understanding to hypothesize which adaptations might be present in plants pictured in two different habitats.

Instructional Focus

In this activity, students identify plant structures that have functions that help the plant survive.

Life Skills **Critical Thinking**

Strategy

The item Identifying Adaptations provides a formative assessment of students' understanding of the nature of adaptation in terms of specific plant structures serving specific functions to meet different environmental conditions. Have student pairs brainstorm their responses together prior to having students write individual responses.

Differentiation

ADVANCED LEARNERS

Challenge students to research an example of an animal characteristic that is not helpful to its survival due to climate change. What difficulties does the animal face due to climate change? How might it adapt to its changing surroundings?

Lesson 4

How Are Body Systems Adapted to Meet the Needs of a Living Thing?

Activity 9
Observe Like a Scientist

15 min

Digestive System

Purpose

The structural adaptations introduced so far have focused on individual features. This activity broadens student understanding of structural adaptations to include body systems of both animals and humans. Before considering how some animal systems have adapted, this activity begins with the familiar: the human digestive system.

Instructional Focus

In this activity, students explore how the digestive system can be described in terms of its component organs and learn that these digestive organs work together as a system.

Strategy

Interactives offer a low-pressure, engaging environment for students to explore and test ideas. If your students cannot access the interactives, text has been provided to support learning.

Before students engage in the interactive, read the text together as a class. Pause periodically to check for understanding and to allow students to ask questions.

If students have digital access, allow students to complete the interactive before answering the questions. Otherwise, provide students time to answer the questions.

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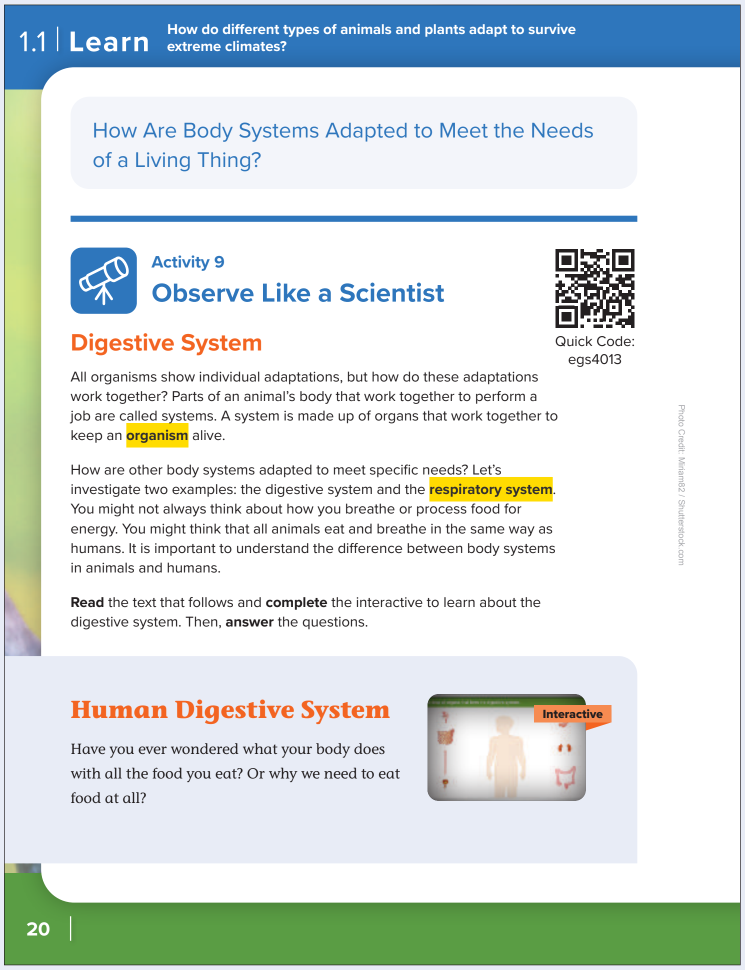
Pages 20–22


1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

How Are Body Systems Adapted to Meet the Needs of a Living Thing?

Activity 9
Observe Like a Scientist

Quick Code: egs4013

Digestive System

All organisms show individual adaptations, but how do these adaptations work together? Parts of an animal's body that work together to perform a job are called systems. A system is made up of organs that work together to keep an **organism** alive.

How are other body systems adapted to meet specific needs? Let's investigate two examples: the digestive system and the **respiratory system**. You might not always think about how you breathe or process food for energy. You might think that all animals eat and breathe in the same way as humans. It is important to understand the difference between body systems in animals and humans.

Read the text that follows and **complete** the interactive to learn about the digestive system. Then, **answer** the questions.

Human Digestive System

Have you ever wondered what your body does with all the food you eat? Or why we need to eat food at all?

Interactive

20

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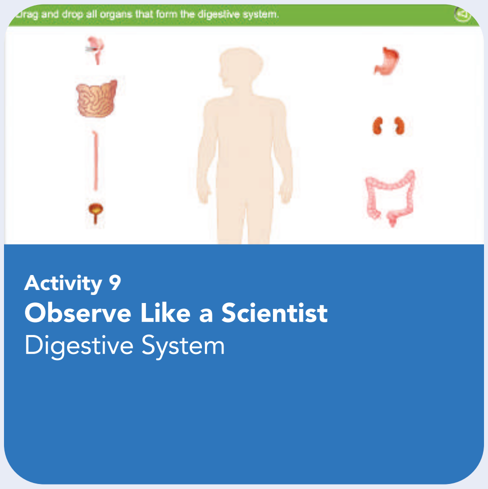

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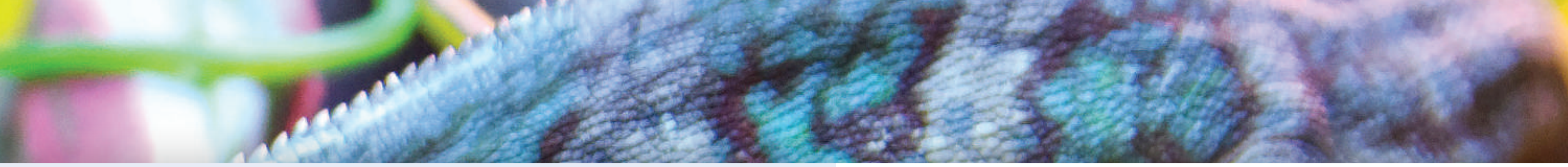

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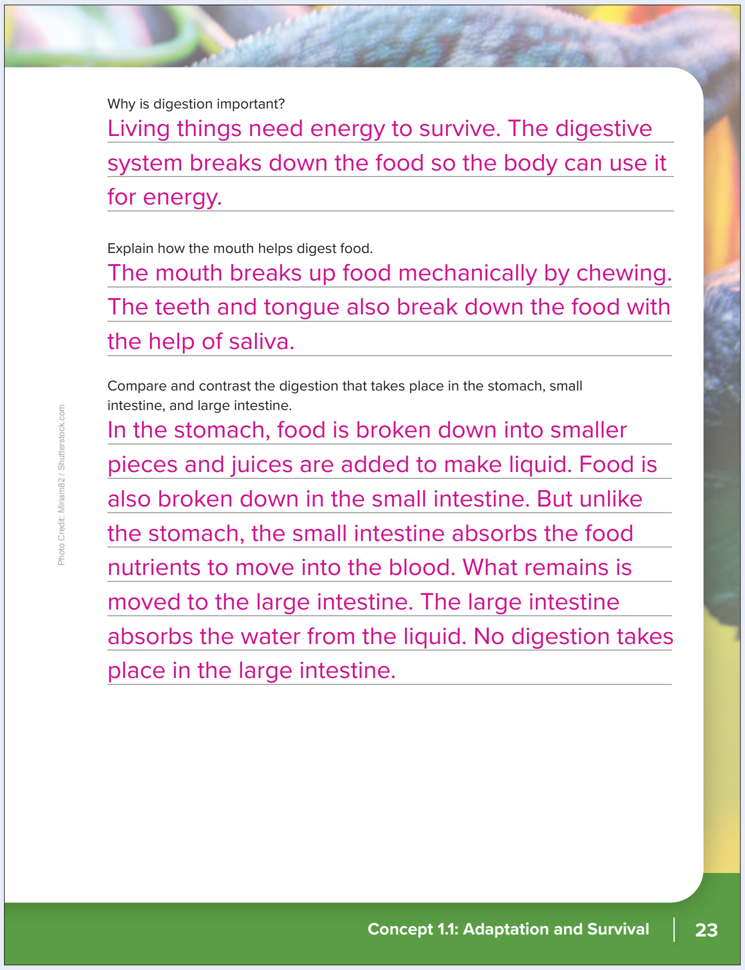

Why is digestion important?

Living things need energy to survive. The digestive system breaks down the food so the body can use it for energy.

Explain how the mouth helps digest food.

The mouth breaks up food mechanically by chewing. The teeth and tongue also break down the food with the help of saliva.

Compare and contrast the digestion that takes place in the stomach, small intestine, and large intestine.

In the stomach, food is broken down into smaller pieces and juices are added to make liquid. Food is also broken down in the small intestine. But unlike the stomach, the small intestine absorbs the food nutrients to move into the blood. What remains is moved to the large intestine. The large intestine absorbs the water from the liquid. No digestion takes place in the large intestine.

Lesson 4, *continued*

Students work independently or with a partner on an interactive, identifying the organs of the digestive system. If multiple devices are available, group students to complete the interactive together. If multiple devices are not available, call on a few students to use the interactive as a class demonstration (projected, if possible) while others watch and take notes.

Students review the interactive to complete written responses. Encourage students to build upon their written responses during class discussion.

ASK

- *How do the organs of the digestive system fit and work together?*
  The digestive organs are connected and organized so that food follows a process from the beginning of digestion in the mouth to the elimination of waste.

After students have answered the questions, facilitate a discussion on how to keep the digestive system in our bodies healthy. Ask students to share what they already know, such as the importance of drinking water, and capture questions they still have about digestive system health. Encourage students to research their questions independently and share what they learn with the class in the concept review.

ASK

- *Why is digestion necessary?*
  Digestion breaks down food into chemicals that the body can absorb and use for energy and growth.
- *What happens to food in the stomach compared with what happens to it in the small intestine?*
  In the stomach, acids break food down into its component chemicals. In the small intestine, cells lining the inside absorb the chemicals.
- *How does the mouth help digest food?*
  Digestion starts in the mouth, where food is broken down by mechanical action of chewing, and saliva starts to break the food down chemically.

Lesson 4, *continued*

Activity 10
Analyze Like a Scientist

15 min

Body Systems

Purpose
This activity introduces how multiple adaptations of organs within systems work together to help animals survive.

Instructional Focus
In this activity, students communicate how internal structures, such as the digestive system, help animals survive.

Strategy
Prior to reading Body Systems, ask students to review and share aloud the organs in the human digestive system.

ASK

- *What is the overall function of the digestive system?*
  To extract the nutrients our bodies need from the food we eat.
- *What would happen if any organ in the system were missing?*
  If one of the parts of the system was missing, it would not function properly.

Refer students to the diagrams provided in the article. After briefly reviewing the image, ask students to predict the topic of the reading passage.

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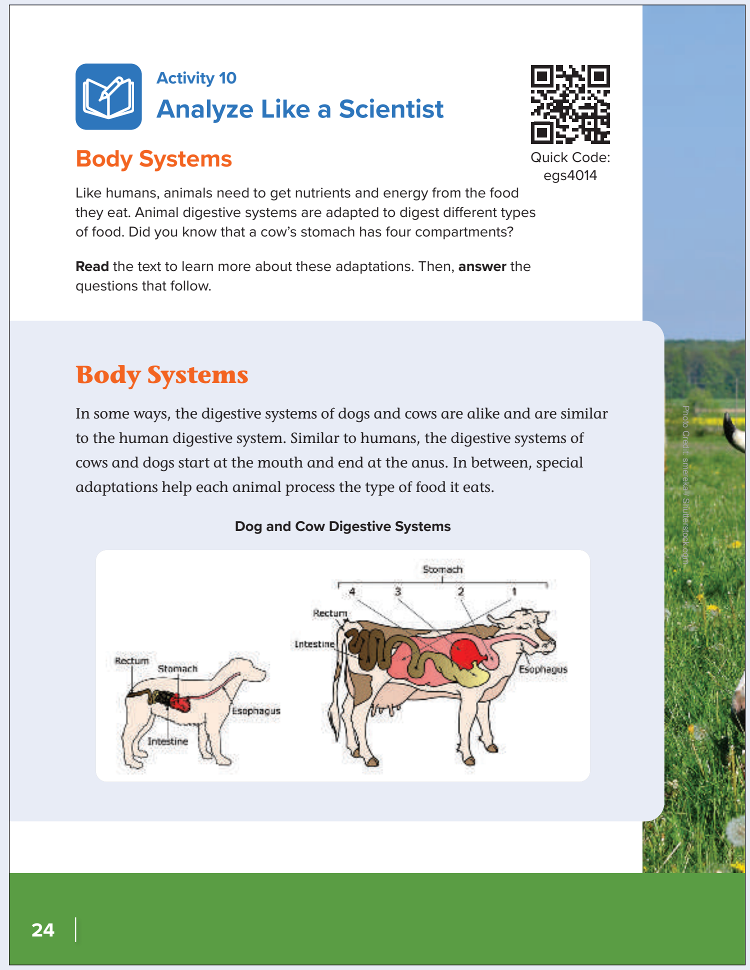
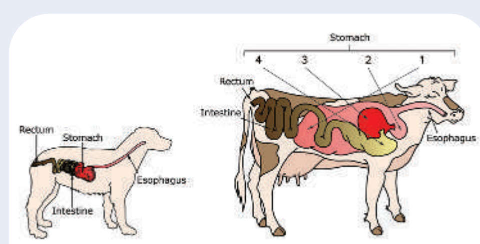
Page 24

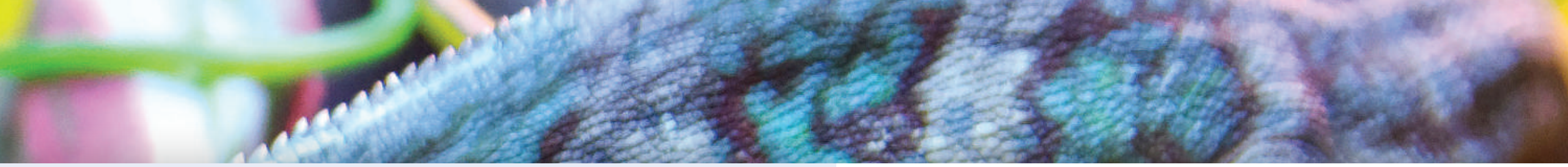

Activity 10
Analyze Like a Scientist
Body Systems
Quick Code: egs4014
Like humans, animals need to get nutrients and energy from the food they eat. Animal digestive systems are adapted to digest different types of food. Did you know that a cow's stomach has four compartments?
Read the text to learn more about these adaptations. Then, **answer** the questions that follow.
Body Systems
In some ways, the digestive systems of dogs and cows are alike and are similar to the human digestive system. Similar to humans, the digestive systems of cows and dogs start at the mouth and end at the anus. In between, special adaptations help each animal process the type of food it eats.
Dog and Cow Digestive Systems
Stomach
4 3 2 1
Rectum
Intestine
Esophagus
Rectum
Stomach
Esophagus
Intestine
24

DIGITAL



Activity 10
Analyze Like a Scientist
Body Systems

Quick Code:
egst4014



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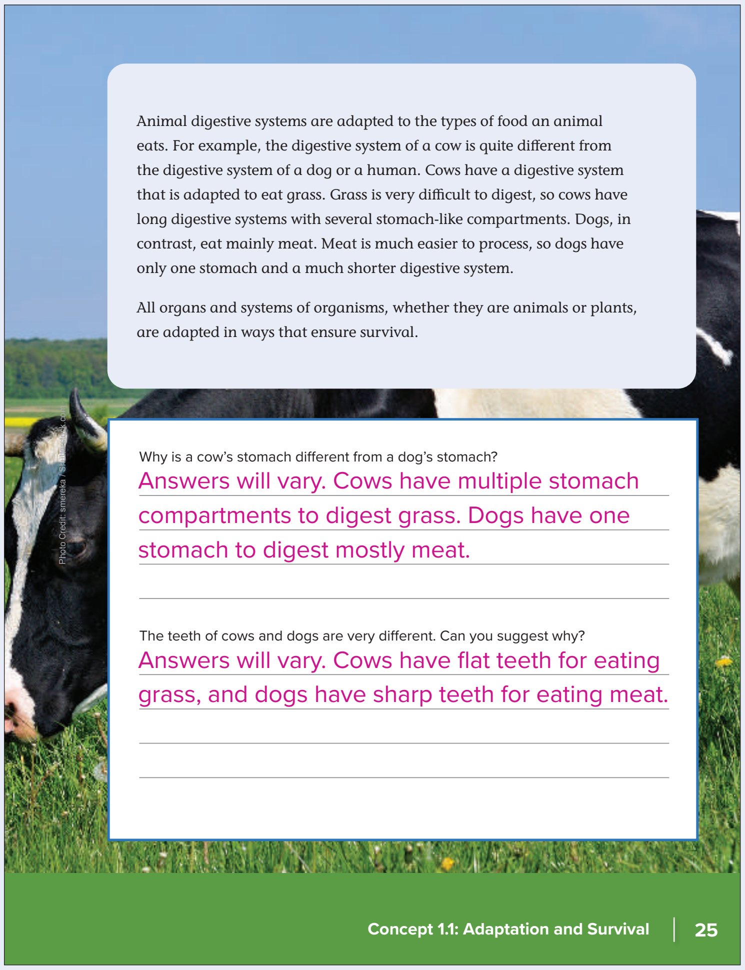

Animal digestive systems are adapted to the types of food an animal eats. For example, the digestive system of a cow is quite different from the digestive system of a dog or a human. Cows have a digestive system that is adapted to eat grass. Grass is very difficult to digest, so cows have long digestive systems with several stomach-like compartments. Dogs, in contrast, eat mainly meat. Meat is much easier to process, so dogs have only one stomach and a much shorter digestive system.

All organs and systems of organisms, whether they are animals or plants, are adapted in ways that ensure survival.

Why is a cow's stomach different from a dog's stomach?

Answers will vary. Cows have multiple stomach compartments to digest grass. Dogs have one stomach to digest mostly meat.

The teeth of cows and dogs are very different. Can you suggest why?

Answers will vary. Cows have flat teeth for eating grass, and dogs have sharp teeth for eating meat.

Concept 1.1: Adaptation and Survival | 25

Lesson 4, *continued*

Direct students to read Body Systems with a partner and take turns sharing interesting facts from the reading. Partners can work together to respond to the questions at the end of the text, referring to the text for answers.

Organize students in small groups to have a collaborative discussion about structure and function as it relates to body systems. Students should define structures and functions and share what they know about the structures and functions of the digestive systems.

ASK

- *How are these systems similar and different for each of these animals?*
  Both animals have stomachs, but the cow has many stomach compartments. Dogs have only one. One is built to digest meat, the other digests grass.
- *What do you think would happen to cows if their digestive systems were not adapted to eating grass?*
  Cows would have to have to find something else to eat or they would not survive.
- *What questions do you have about body systems and adaptation?*
  Answers will vary.

Lesson 4, *continued*

Activity 11
Observe Like a Scientist

15 min

Respiratory System

Purpose

In this activity, students are introduced to how the human respiratory system works to help keep people active and alive. Understanding how the human body works will support students as they go on to learn about the unique respiratory adaptations of other organisms.

Instructional Focus

In this activity, students explore the parts and functions of the respiratory system and study how these parts work together and adapt as a system.

Strategy

Interactives offer a low-pressure and engaging environment for students to explore and test ideas. If your students cannot access the interactive, text has been provided to support learning.

Before students engage in the interactive or read the text, ask students to draw attention to their own breathing. Encourage them to pay careful attention to what happens as they inhale and exhale. Ask students to place one hand on their stomach and another on their rib cage. Give students time to observe what happens as they inhale and exhale. Invite students to share their observations.

Next, read the text together as a class. Stop periodically to check for understanding and to allow students to ask questions.

If students have digital access, allow students to complete the interactive before answering the questions. Otherwise, provide students time to answer the questions.

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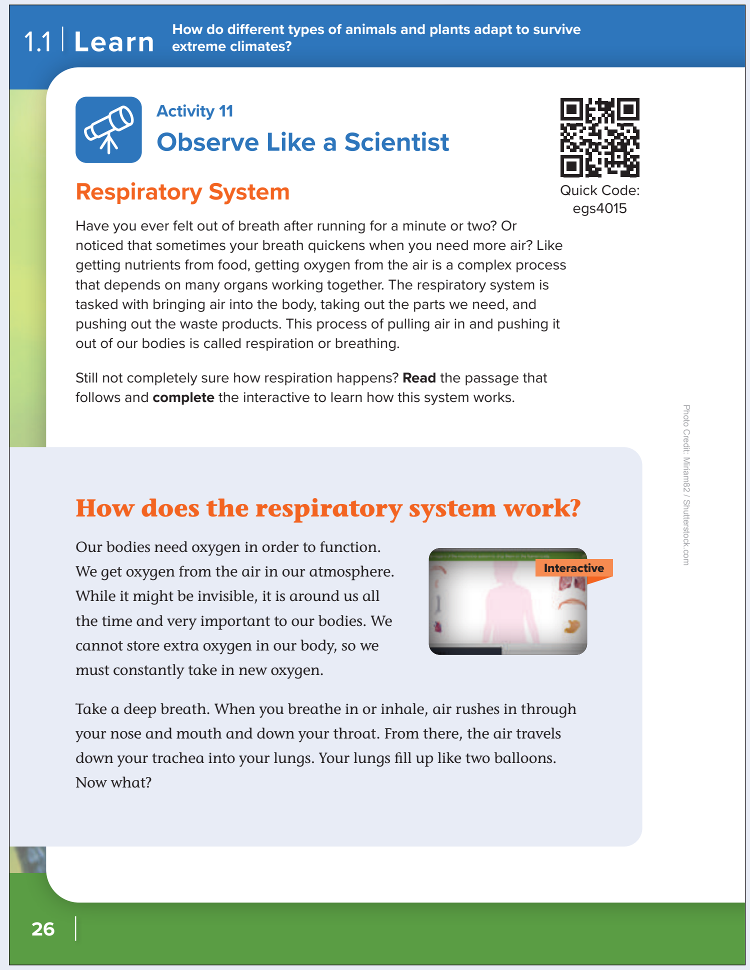
Pages 26–27



1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

Activity 11
Observe Like a Scientist

Quick Code: egs4015

Respiratory System

Have you ever felt out of breath after running for a minute or two? Or noticed that sometimes your breath quickens when you need more air? Like getting nutrients from food, getting oxygen from the air is a complex process that depends on many organs working together. The respiratory system is tasked with bringing air into the body, taking out the parts we need, and pushing out the waste products. This process of pulling air in and pushing it out of our bodies is called respiration or breathing.

Still not completely sure how respiration happens? **Read** the passage that follows and **complete** the interactive to learn how this system works.

How does the respiratory system work?

Our bodies need oxygen in order to function. We get oxygen from the air in our atmosphere. While it might be invisible, it is around us all the time and very important to our bodies. We cannot store extra oxygen in our body, so we must constantly take in new oxygen.

Interactive

Take a deep breath. When you breathe in or inhale, air rushes in through your nose and mouth and down your throat. From there, the air travels down your trachea into your lungs. Your lungs fill up like two balloons. Now what?

26

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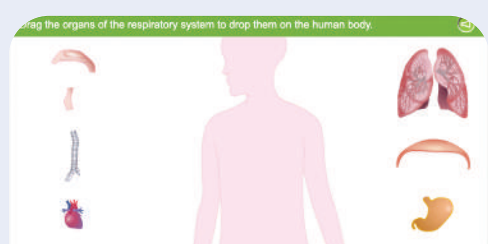
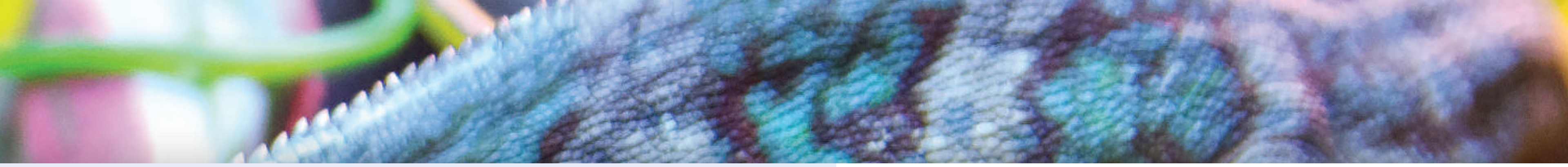


Activity 11
Observe Like a Scientist
Respiratory System

Quick Code:
egst4015



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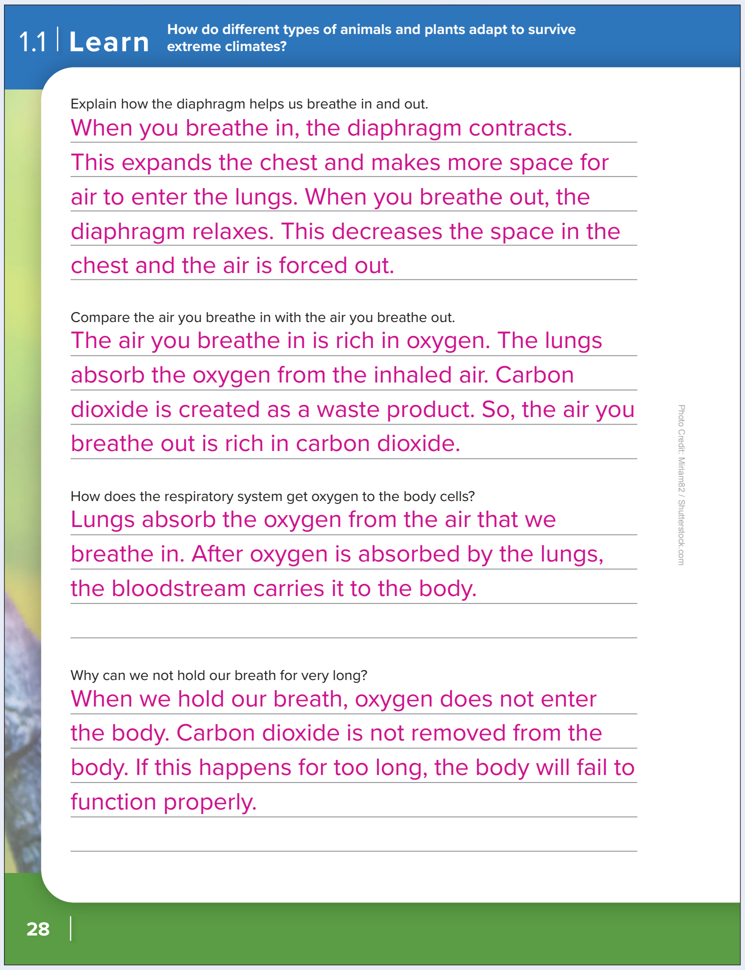

1.1 | Learn How do different types of animals and plants adapt to survive extreme climates?

Explain how the diaphragm helps us breathe in and out.

When you breathe in, the diaphragm contracts. This expands the chest and makes more space for air to enter the lungs. When you breathe out, the diaphragm relaxes. This decreases the space in the chest and the air is forced out.

Compare the air you breathe in with the air you breathe out.

The air you breathe in is rich in oxygen. The lungs absorb the oxygen from the inhaled air. Carbon dioxide is created as a waste product. So, the air you breathe out is rich in carbon dioxide.

How does the respiratory system get oxygen to the body cells?

Lungs absorb the oxygen from the air that we breathe in. After oxygen is absorbed by the lungs, the bloodstream carries it to the body.

Why can we not hold our breath for very long?

When we hold our breath, oxygen does not enter the body. Carbon dioxide is not removed from the body. If this happens for too long, the body will fail to function properly.

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Lesson 4, *continued*

Students will use this interactive to identify the parts of the respiratory system. They will observe the breathing process and learn about the exchange of oxygen and carbon dioxide in the lungs. If multiple devices are available, group students to complete the interactive together. If multiple devices are not available, call on a few students to use the interactive as a class demonstration (projected, if possible) while others watch and take notes.

Encourage students to engage in scientific conversation with peers to share their answers. Recommend that students actively listen to each other by rephrasing a partner's ideas back to the partner. To expand their own thinking, students should ask each other questions such as, *Can you say more about that? What do you mean by that? What specific examples from the interactive support what you are saying?*

After students have answered the questions, facilitate a discussion on how what behaviors increase and decrease the health of the respiratory system in our bodies. Ask students to share what they already know, such as the importance of breathing clean air and not smoking, and capture questions they still have about respiratory system health. Students will learn more about the health of the respiratory system in the next unit.

Lesson 5

Activity 12
Observe Like a Scientist

20 min

How Fish Breathe

Purpose

In this activity, students build upon their understanding of how the respiratory system in the human body functions. Using knowledge of their own body systems, students explore how the unique adaptation of gills in fish helps these animals to survive in an underwater habitat.

Instructional Focus

In this activity, students compare the structures of respiratory systems of a fish to those of a human.

Life Skills **Decision-Making**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before watching the video, ask students to read the text How Fish Breathe. If students have digital access, instruct them to watch the video before completing the table.

This video shows how fish use their gills to breathe underwater. Show the video to students from the 2:06 mark.

- Students should look for the structure that fish use to breathe underwater.
- After viewing, have pairs or small groups of students discuss the similarities of the human respiratory system and the fish respiratory system.
- To assess student understanding of the concepts in the video, ask them how they would describe what they observed. Then, encourage them to share any questions that came to mind as they observed the video. Work with students to answer their own questions.

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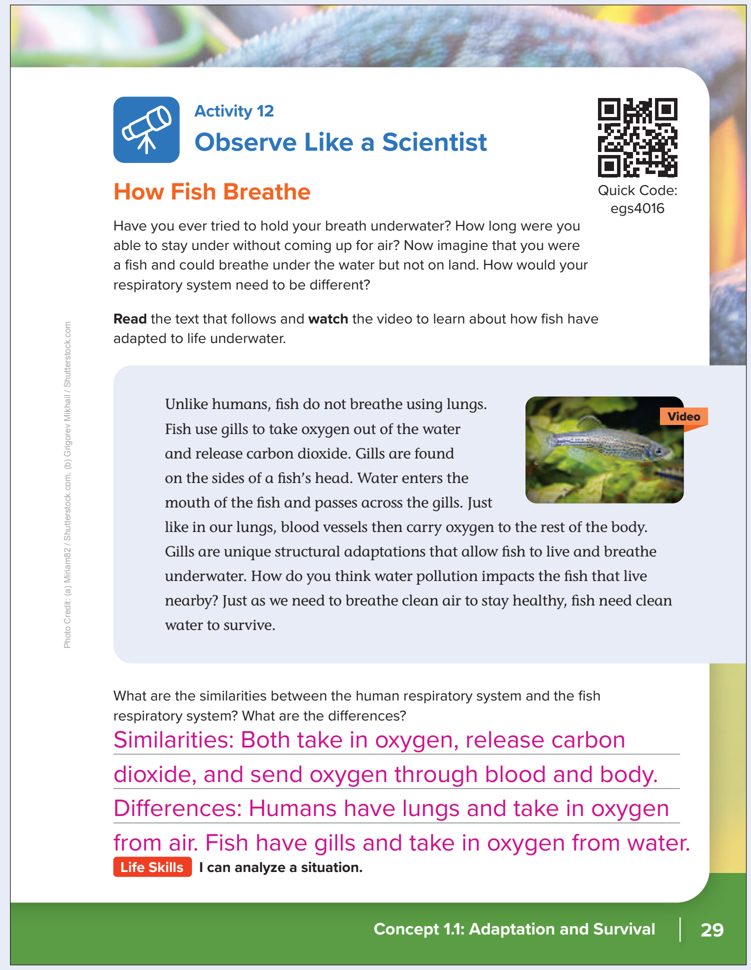
Activity 12

Observe Like a Scientist

How Fish Breathe

Quick Code: egs4016

Have you ever tried to hold your breath underwater? How long were you able to stay under without coming up for air? Now imagine that you were a fish and could breathe under the water but not on land. How would your respiratory system need to be different?

Read the text that follows and **watch** the video to learn about how fish have adapted to life underwater.

Unlike humans, fish do not breathe using lungs. Fish use gills to take oxygen out of the water and release carbon dioxide. Gills are found on the sides of a fish's head. Water enters the mouth of the fish and passes across the gills. Just like in our lungs, blood vessels then carry oxygen to the rest of the body. Gills are unique structural adaptations that allow fish to live and breathe underwater. How do you think water pollution impacts the fish that live nearby? Just as we need to breathe clean air to stay healthy, fish need clean water to survive.

Video

What are the similarities between the human respiratory system and the fish respiratory system? What are the differences?

Similarities: Both take in oxygen, release carbon dioxide, and send oxygen through blood and body. Differences: Humans have lungs and take in oxygen from air. Fish have gills and take in oxygen from water.

Life Skills I can analyze a situation.

Concept 1.1: Adaptation and Survival | 29

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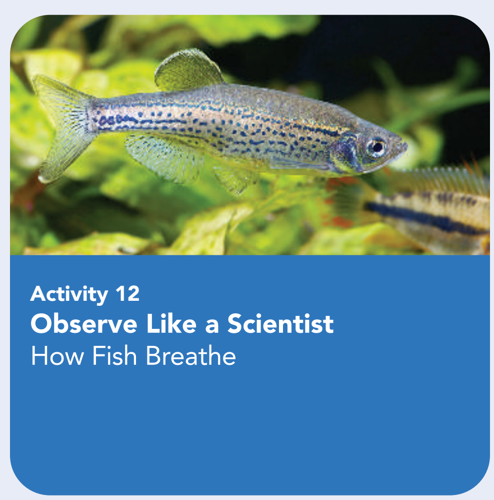

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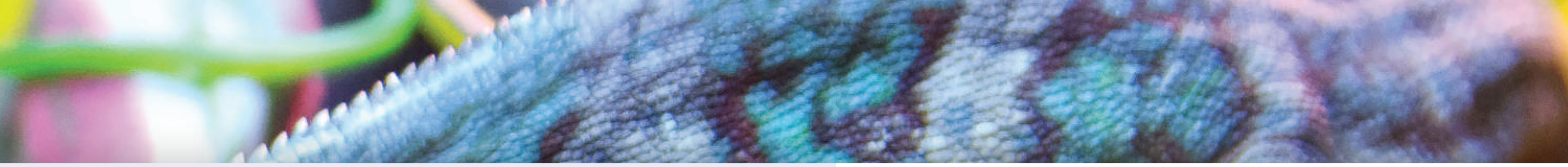

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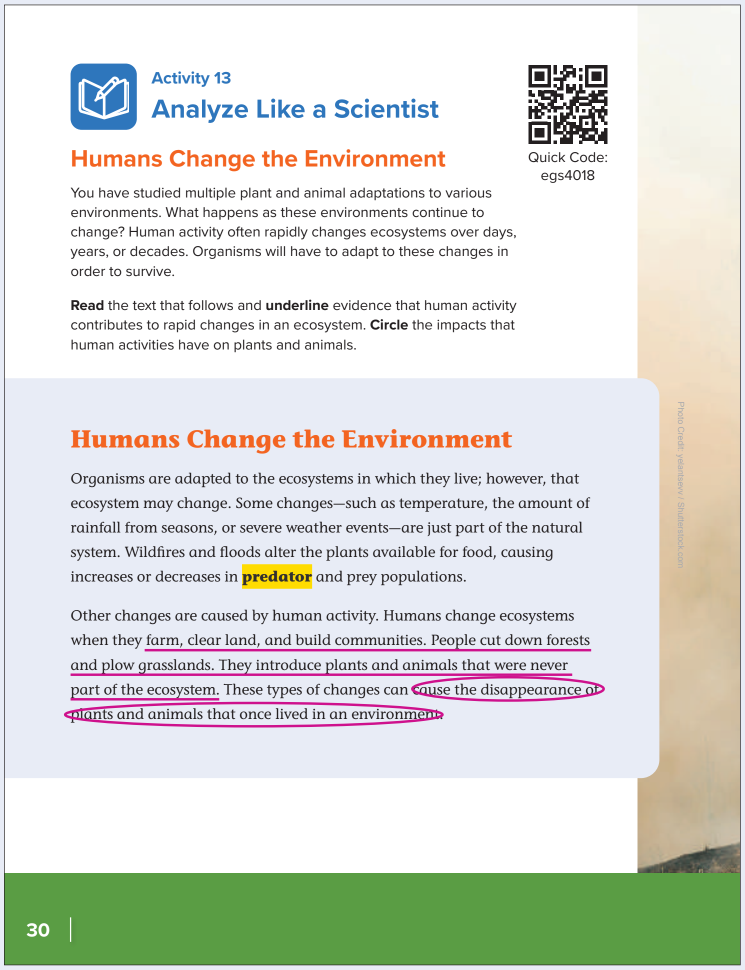
Activity 13

Analyze Like a Scientist

Humans Change the Environment

Quick Code: egs4018

You have studied multiple plant and animal adaptations to various environments. What happens as these environments continue to change? Human activity often rapidly changes ecosystems over days, years, or decades. Organisms will have to adapt to these changes in order to survive.

Read the text that follows and **underline** evidence that human activity contributes to rapid changes in an ecosystem. **Circle** the impacts that human activities have on plants and animals.

Humans Change the Environment

Organisms are adapted to the ecosystems in which they live; however, that ecosystem may change. Some changes—such as temperature, the amount of rainfall from seasons, or severe weather events—are just part of the natural system. Wildfires and floods alter the plants available for food, causing increases or decreases in **predator** and prey populations.

Other changes are caused by human activity. Humans change ecosystems when they farm, clear land, and build communities. People cut down forests and plow grasslands. They introduce plants and animals that were never part of the ecosystem. These types of changes can cause the disappearance of plants and animals that once lived in an environment.

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Photo Credit: yelantsevv / Shutterstock.com

DIGITAL

Activity 13
Analyze Like a Scientist
Humans Change the Environment

Quick Code:
egst4018

Lesson 5, *continued*

Activity 13
Analyze Like a Scientist

10 min

Humans Change the Environment

Purpose

In this activity, students consider multiple factors that cause the environmental changes that give rise to animal and plant adaptations over time. Considering the human role in environmental changes reinforces for students the importance of taking care of the world around them.

Instructional Focus

In this activity, students identify causal relationships between humans and the environment and how living things adapt to environmental changes.

Strategy

Students read the text section and watch the video about how organisms respond to changes in the ecosystem.

As a class, read the first paragraph of the text together. Provide guidance and support as necessary. Students underline any evidence in the text that humans have changed the ecosystem. Students circle text that describes the impact human activities have on plants and animals.

Show students the video Sea Ice. Remind students of the penguins in Activity 2.

Lesson 5, *continued*

ASK

- *What evidence do scientists have that the Arctic climate is changing?*
  Satellite images show that the area covered by old sea ice is diminishing over time. Images observed over time show that much more of the ice is thinner and younger.

- *If the same climate changes that scientists have observed in the region surrounding the North Pole were to happen in the region surrounding the South Pole, how could this affect the penguins living there?*
  Answers will vary. Penguins would have to adapt to the changes. They may have larger gaps between icebergs in which to swim. The areas where they take care of their young might change. Predator or prey populations might change.

Allow students to continue reading the rest of the text independently or with a partner. Students should continue to mark up the text as previously directed. Support students in summarizing their learning by asking the following question:

ASK *What are some cause-and-effect relationships between human actions and ecosystems?*
When human actions change an ecosystem, plants and animals living in that ecosystem may need to change their behavior to survive. Plants and animals may develop structural and behavioral adaptations in response to the changes to the ecosystem.

Prompt students to discuss one negative change caused by humans and one positive change caused by humans.

To culminate the activity, direct students to construct an explanation about possible effects of human changes to an environment. Encourage students to record any questions they have at this time.

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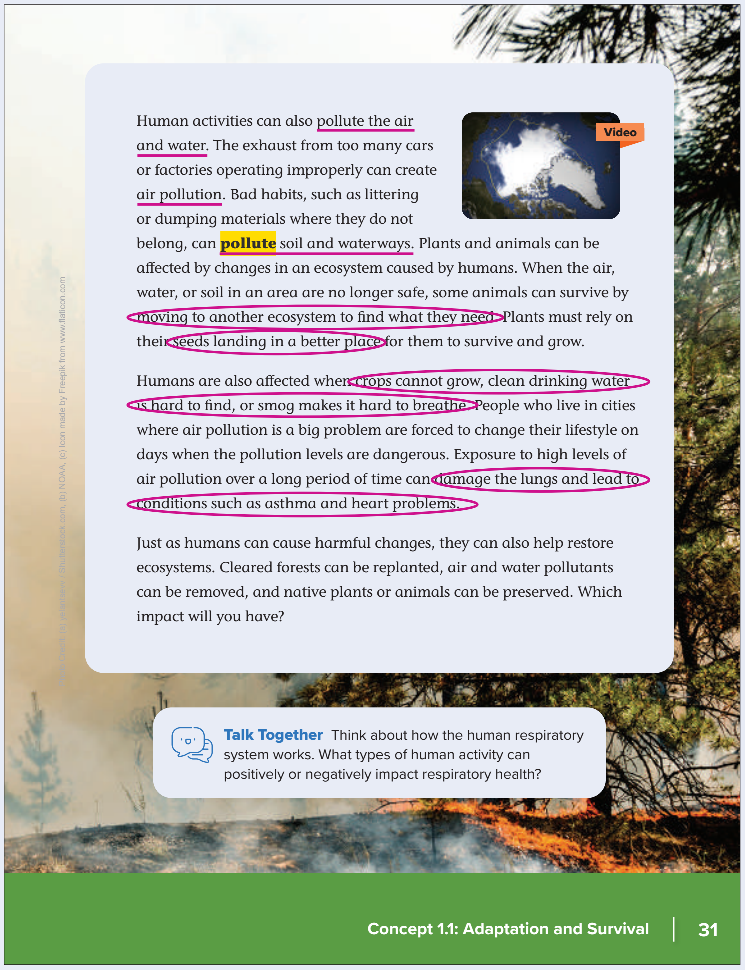

Human activities can also pollute the air and water. The exhaust from too many cars or factories operating improperly can create air pollution. Bad habits, such as littering or dumping materials where they do not belong, can **pollute** soil and waterways. Plants and animals can be affected by changes in an ecosystem caused by humans. When the air, water, or soil in an area are no longer safe, some animals can survive by moving to another ecosystem to find what they need. Plants must rely on their seeds landing in a better place for them to survive and grow.

Humans are also affected when crops cannot grow, clean drinking water is hard to find, or smog makes it hard to breathe. People who live in cities where air pollution is a big problem are forced to change their lifestyle on days when the pollution levels are dangerous. Exposure to high levels of air pollution over a long period of time can damage the lungs and lead to conditions such as asthma and heart problems.

Just as humans can cause harmful changes, they can also help restore ecosystems. Cleared forests can be replanted, air and water pollutants can be removed, and native plants or animals can be preserved. Which impact will you have?

Talk Together Think about how the human respiratory system works. What types of human activity can positively or negatively impact respiratory health?

Video

Concept 1.1: Adaptation and Survival | 31

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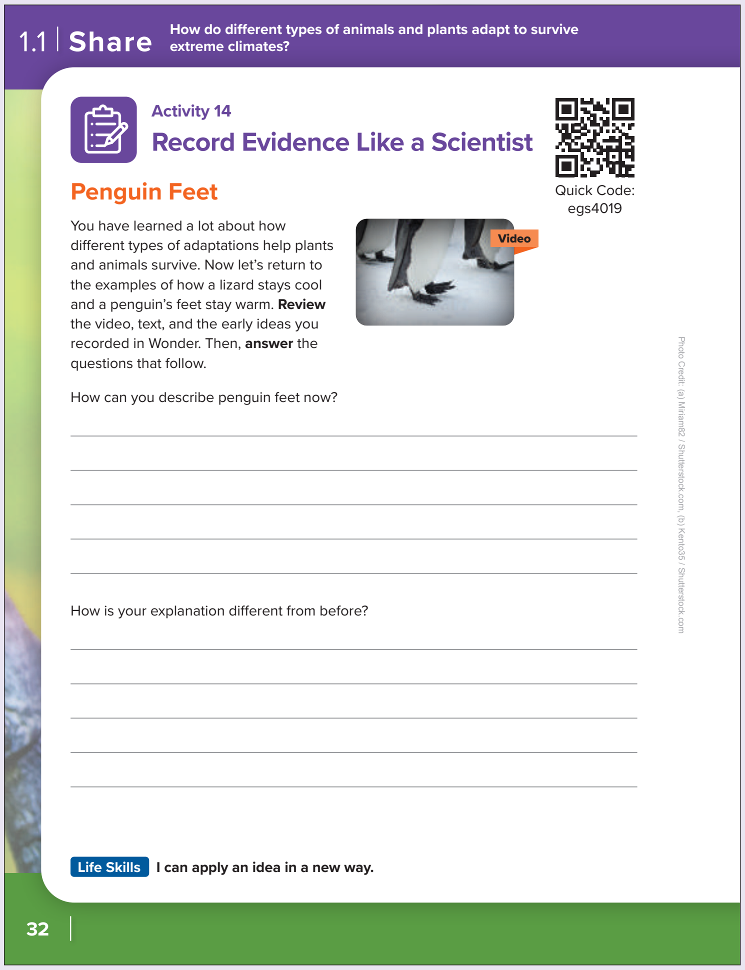
1.1 | Share How do different types of animals and plants adapt to survive extreme climates?

Activity 14
Record Evidence Like a Scientist

Quick Code: egs4019

Penguin Feet

You have learned a lot about how different types of adaptations help plants and animals survive. Now let's return to the examples of how a lizard stays cool and a penguin's feet stay warm. **Review** the video, text, and the early ideas you recorded in Wonder. Then, **answer** the questions that follow.

Video

How can you describe penguin feet now?

How is your explanation different from before?

Life Skills I can apply an idea in a new way.

Photo Credit: (a) Miriam82 / Shutterstock.com, (b) Kento35 / Shutterstock.com

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Photo Credit: Kento35 / Shutterstock.com

DIGITAL

Activity 14
Record Evidence Like a Scientist
Penguin Feet

Quick Code:
egst4019

Lesson 5, *continued*

Scientific Explanation

Activity 14
Record Evidence Like a Scientist

15 min

Penguin Feet

Purpose

In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students construct explanations about how living things use adaptations to survive in an environment.

Life Skills **Creativity**

Strategy

Display the Can You Explain? question. Refer students to questions they asked during the initial viewing of the *Penguin Feet* video.

Replay the *Penguin Feet* video. Allow time for students to discuss the Talk Together questions with a partner.

Begin a whole group discussion in which students share their new understandings. The discussion should be broad, going beyond the *Penguin Feet* video to what they now understand about adaptation and survival.

Lesson 5, *continued*

ASK

- *What do you now know that can explain the phenomenon of Penguin Feet seen in the video?*
  Student responses will vary.
- *How can this help us understand adaptation and survival in other organisms?*
  Student responses will vary.
- *What do you now know that helps you answer the Can You Explain? question or one of your own questions?*
  Student responses will vary.

Can You Explain?

How do different types of animals and plants adapt to survive extreme climates?

Throughout the course, students will develop the skill of communicating scientific information in writing, specifically by learning to write a scientific explanation. Students begin building this skill by considering what evidence they have gathered to answer the question posed at the beginning of the concept. Instruct students to review evidence gained from multiple activities with a partner and record notes in the space provided.

Then, encourage students to write an answer to the Can You Explain? question in full sentences, incorporating at least two pieces of evidence in support of their response.

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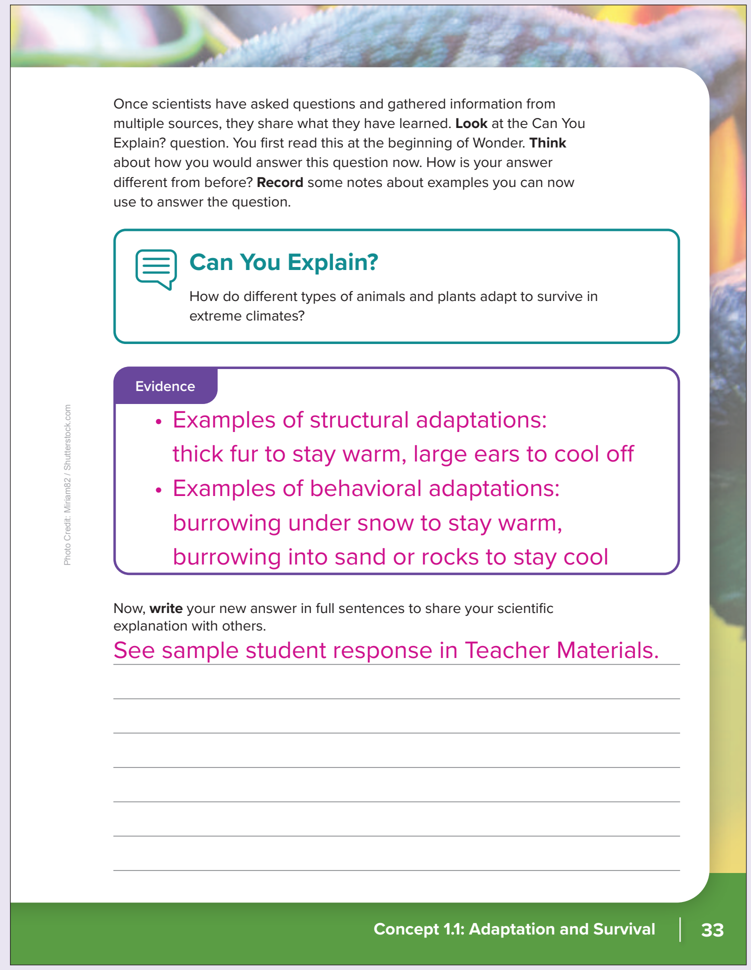

Once scientists have asked questions and gathered information from multiple sources, they share what they have learned. **Look** at the Can You Explain? question. You first read this at the beginning of Wonder. **Think** about how you would answer this question now. How is your answer different from before? **Record** some notes about examples you can now use to answer the question.

Can You Explain?

How do different types of animals and plants adapt to survive in extreme climates?

Evidence

- Examples of structural adaptations: thick fur to stay warm, large ears to cool off
- Examples of behavioral adaptations: burrowing under snow to stay warm, burrowing into sand or rocks to stay cool

Now, **write** your new answer in full sentences to share your scientific explanation with others.

See sample student response in Teacher Materials.

Concept 1.1: Adaptation and Survival | 33

Sample student response:
Animals and plants have adapted over time to survive in extreme climates by changing their behavior and physical characteristics. An example of a physical characteristic that helps an animal survive extreme cold would be a layer of fat or a thick fur coat. A behavioral change might be foxes and other animals that burrow to keep warm in the cold or cool in extreme heat. Some plants have adapted to cold, snowy environments by growing flexible branches that bend instead of break under the weight of snow. All animals and plants must have adaptations to survive the challenges of the environments where they live.

Differentiation

APPROACHING LEARNERS

Some of the vocabulary words, such as *adapt* and *migration*, may be confusing to students because they have other meanings in different contexts. Have students make a list of any words like this that they've heard elsewhere and make sure that their definitions are correct for this context.

Teacher Reflection

How did I provide scaffolding for students to construct their scientific explanations?

Lesson 6

STEM in Action

Activity 15
Analyze Like a Scientist

25 min

Careers and Adaptation

Purpose

This activity connects adaptations in organisms to the idea that human activity may pose threats to the natural world. Students gather information about the work being done by conservation biologists to save frogs and then consider how students might also help with conservation efforts.

Instructional Focus

In this activity, students obtain information about the work of conservation biologists and evaluate the information to communicate why researchers study adaptations in endangered amphibians. Students then design a public service message to advocate for clean waterways.

Life Skills **Problem-Solving**

Strategy

After reading the article, either in pairs or as a class, prompt students to complete the assessment questions below.

Once completed, invite students to share their answers to the first question. Use their responses to generate discussion about the work done by conservationists, field biologists, and researchers. Discuss with students how researchers use their knowledge about specific adaptations to protect amphibians.

Encourage students to share any experiences that they may have had with or knowledge that they have of amphibians in their local environment. The Nile Delta toad is an example of an amphibian found in Egypt that students may be familiar with.

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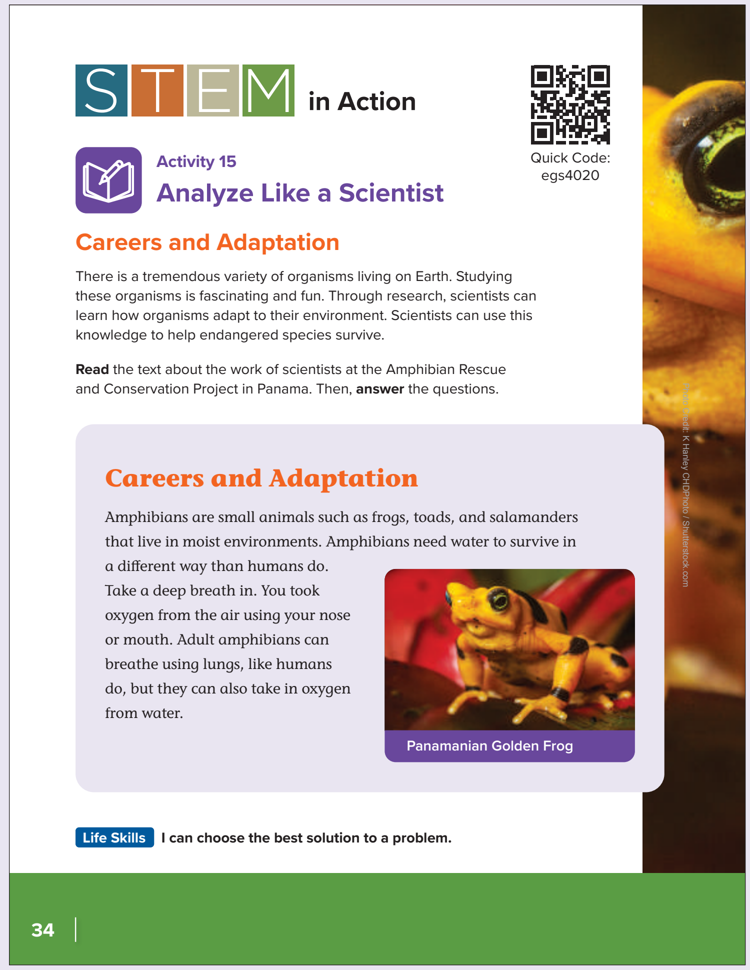
Pages 34–35


STEM in Action

Quick Code: egs4020

Activity 15
Analyze Like a Scientist

Careers and Adaptation

There is a tremendous variety of organisms living on Earth. Studying these organisms is fascinating and fun. Through research, scientists can learn how organisms adapt to their environment. Scientists can use this knowledge to help endangered species survive.

Read the text about the work of scientists at the Amphibian Rescue and Conservation Project in Panama. Then, **answer** the questions.

Careers and Adaptation

Amphibians are small animals such as frogs, toads, and salamanders that live in moist environments. Amphibians need water to survive in a different way than humans do. Take a deep breath in. You took oxygen from the air using your nose or mouth. Adult amphibians can breathe using lungs, like humans do, but they can also take in oxygen from water.

Panamanian Golden Frog

Life Skills I can choose the best solution to a problem.

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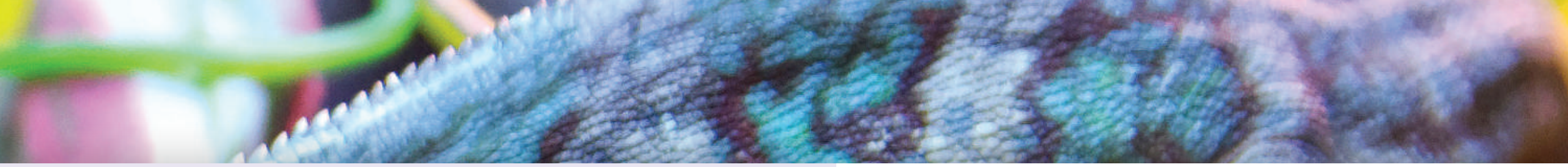
Activity 15
Analyze Like a Scientist
Careers and Adaptation

Quick Code:
egst4020



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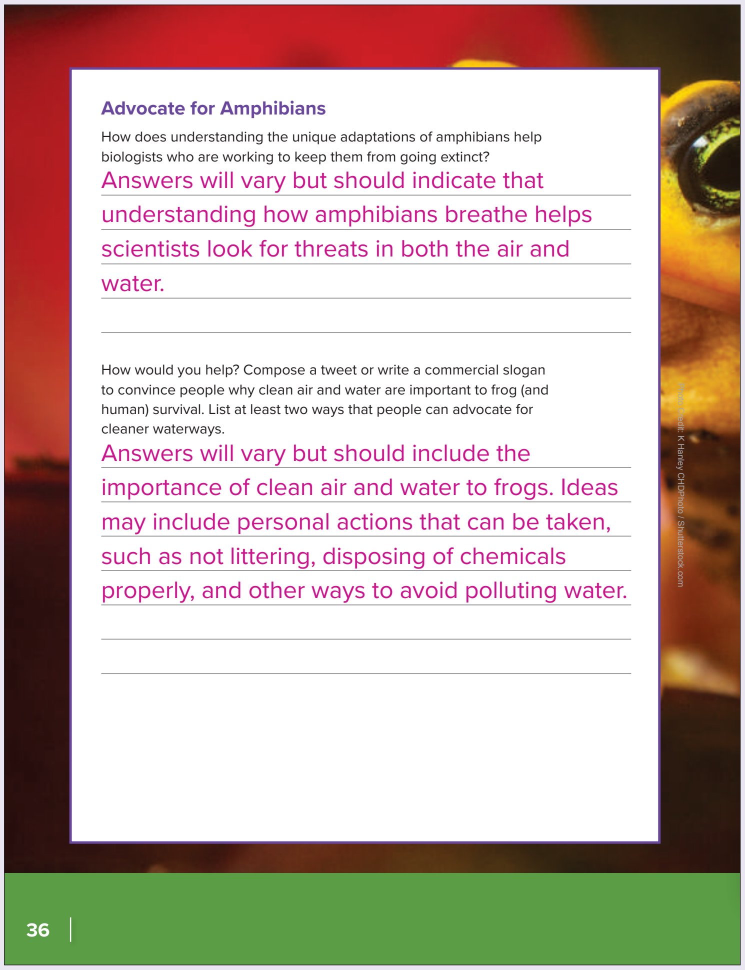

Advocate for Amphibians

How does understanding the unique adaptations of amphibians help biologists who are working to keep them from going extinct?

Answers will vary but should indicate that understanding how amphibians breathe helps scientists look for threats in both the air and water.

How would you help? Compose a tweet or write a commercial slogan to convince people why clean air and water are important to frog (and human) survival. List at least two ways that people can advocate for cleaner waterways.

Answers will vary but should include the importance of clean air and water to frogs. Ideas may include personal actions that can be taken, such as not littering, disposing of chemicals properly, and other ways to avoid polluting water.

Photo Credit: K Hanley CHDPhoto / Shutterstock.com

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Lesson 6, *continued*

Next, ask students to share their advocacy ideas, either in small groups or as a whole class. Discuss personal actions that can be taken to aid conservation efforts, as well as how conservation organizations might work toward large-scale protection of endangered animals.

ENTREPRENEURSHIP

Entrepreneurs set goals by determining priorities and action plans. As you read about field biologists, think of ways their work might require the setting of short, medium, and long term goals. How might field biologists and researchers need to adapt to unexpected changes?

Lesson 6, *continued*

Review and Assess

Activity 16
Evaluate Like a Scientist

20 min

Review: Adaptation and Survival

Purpose
The final activity of the concept asks students to review and explain the main ideas of adaptation and survival.

Instructional Focus
Students will summarize their learning about adaptations via a written explanation and by completing a concept summative assessment.

Life Skills **Self-Management**

Strategy
Students use notes to review what has been learned about adaptations and survival. In the summative concept assessment, students will explain core ideas learned. Students explain that adaptations are traits and characteristics that help living things survive and reproduce. Students distinguish structural from behavioral adaptations and outline how body systems are adapted to meet the needs of an organism. Students also explain how human activities impact the survival of organisms.

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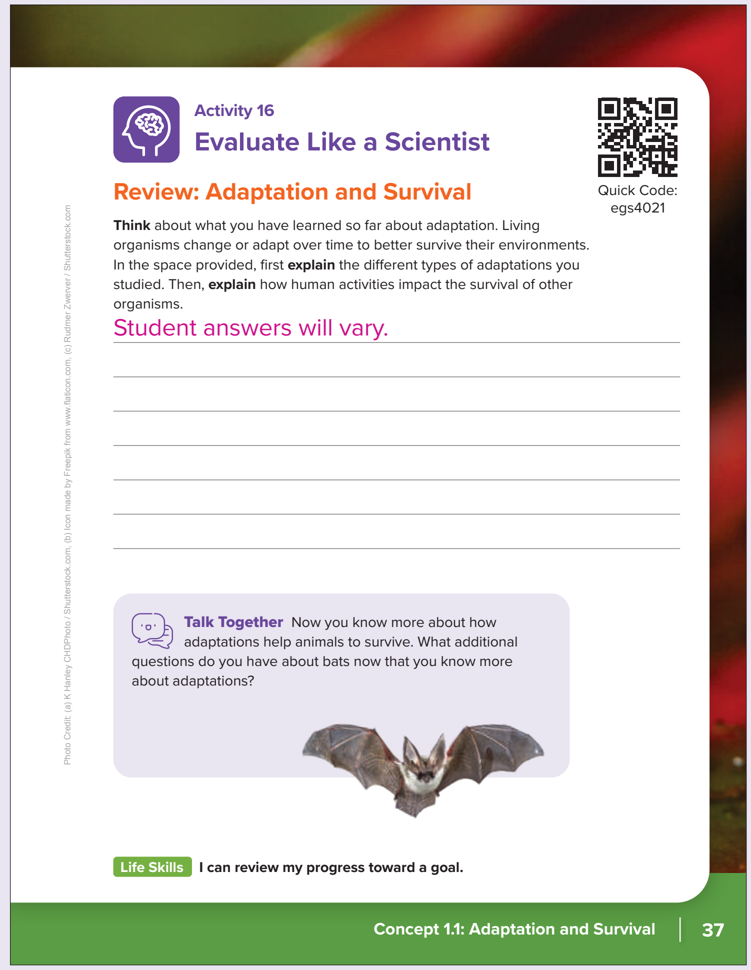
Activity 16
Evaluate Like a Scientist

Quick Code: egs4021

Review: Adaptation and Survival

Think about what you have learned so far about adaptation. Living organisms change or adapt over time to better survive their environments. In the space provided, first **explain** the different types of adaptations you studied. Then, **explain** how human activities impact the survival of other organisms.

Student answers will vary.

Talk Together Now you know more about how adaptations help animals to survive. What additional questions do you have about bats now that you know more about adaptations?

Life Skills I can review my progress toward a goal.

Concept 1.1: Adaptation and Survival | 37

DIGITAL

Activity 16
Evaluate Like a Scientist
Review: Adaptation and Survival

Quick Code:
egst4021

CONCEPT 1.2

Senses at Work

Photo Credit: Arnold O.A. Pinto / Shutterstock.com

Concept Objectives

By the end of this concept, students should be able to:

- Develop models that describe patterns in how animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- Construct explanations based on evidence for how organs and systems work together to process and respond to different sensory data.
- Plan and carry out investigations to produce data to serve as the basis for evidence that vision, hearing, and touch play a role in reaction time.

Quick Code:
egst4022

Key Vocabulary

new: brain, information, nerve, receptor, reflex, senses, sound

Quick Code:
egst4023

Key Vocabulary Strategies

Semantic Map

- As you introduce each vocabulary word to students, have students think of other words that are closely associated with that word. Have students make a list of these words. For example, for the word senses, students might list the words *hearing*, *sight*, *taste*, *touch*, *smell*, etc. Give students the opportunity to share some of their words with the class.
- Categorize all the related words that students shared. Then, create a class map showing the various categories. Create new categories and add new words as needed.

Venn Diagram

- After you have introduced all the vocabulary words, have students create a Venn diagram to compare two terms that name parts of the body. For example, students might label a Venn diagram with *nerve* and *brain* and list similarities and differences between the two body parts.
- Divide students into pairs and have them share their Venn diagrams with each other. Encourage students to revise their diagrams based on feedback from their partners.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	15 min
		Activity 3	10 min
		Activity 4	10 min
Learn	Lesson 2	Activity 5	25 min
		Activity 6	20 min
	Lesson 3	Activity 8	45 min
	Lesson 4	Activity 10	45 min
	Lesson 5	Activity 11	25 min
		Activity 12	20 min
Share	Lesson 6	Activity 14	25 min
		Activity 16	20 min

Content Background

In Concept 1, students were introduced to organisms that survive in extreme climates, thanks to unique sets of behavioral and structural adaptations. The ability to thrive, grow, and live long enough to reproduce in extreme conditions often requires that animals also have specialized senses tailored to the conditions of their environment. However, no sensory system works in isolation. In order for the information captured by the sensory organs to be useful, the processing of these messages must also be efficient.

Sensory Organs and the Nervous System

Animals receive, transmit, and process sensory information through the nervous system. The nervous system includes sensory organs that receive information, nerves that transmit information, and the brain, which processes information. Each animal has unique sensory organs. In humans, these organs are the eyes, ears, nose, mouth, and skin. These organs receive environmental stimuli. The stimuli are translated into electrical impulses, which are transmitted through nerves. The nerves carry the information to the command center of the nervous system—the brain—where it is processed. The brain then sends messages via the nerves to the rest of the body explaining how to react to the stimuli.

Stimuli and the Senses

In Concept 2, the human body serves as a familiar entry point for students to begin learning about this biological system of information transfer. Students first reflect upon how human senses serve as a way to navigate danger, find and enjoy food, and recognize friends and family. Students investigate their own response to stimuli by comparing the speed of the nervous system to sight versus sound triggers. Using this as a framework for understanding, students then explore how rapid responses to stimuli are the key to survival in the animal kingdom.

As students move into the next concept, they will use the knowledge that they have gained about senses to dive deeper into the role that light and sight play in allowing animals to hunt and avoid predation while living a nocturnal existence.

Hands-On Investigations Preparation

Learn

Location	Instructional Focus	Materials to Prepare (per group)
Activity 10: Reaction Time	In this activity, students carry out an investigation about reaction time in response to auditory versus visual stimuli.	• Meterstick • Calculator • Chair

Lesson 1

Activity 1
Can You Explain?

10 min

How do animals sense and process information?

Purpose

This activity draws on students' prior knowledge by asking them to explain how animals sense and process information.

Instructional Focus

In this activity, students will use prior knowledge to begin their explanation of how animals use their senses to collect information and process the information to help the animal survive.

Life Skills **Endurance**

Strategy

Encourage students to explain what they already know about how animals sense and process information.

Students may have some initial ideas about how to answer the question (see sample student response in the student edition page). By the end of the concept, students should be able to construct a scientific explanation that includes evidence from the concept activities.

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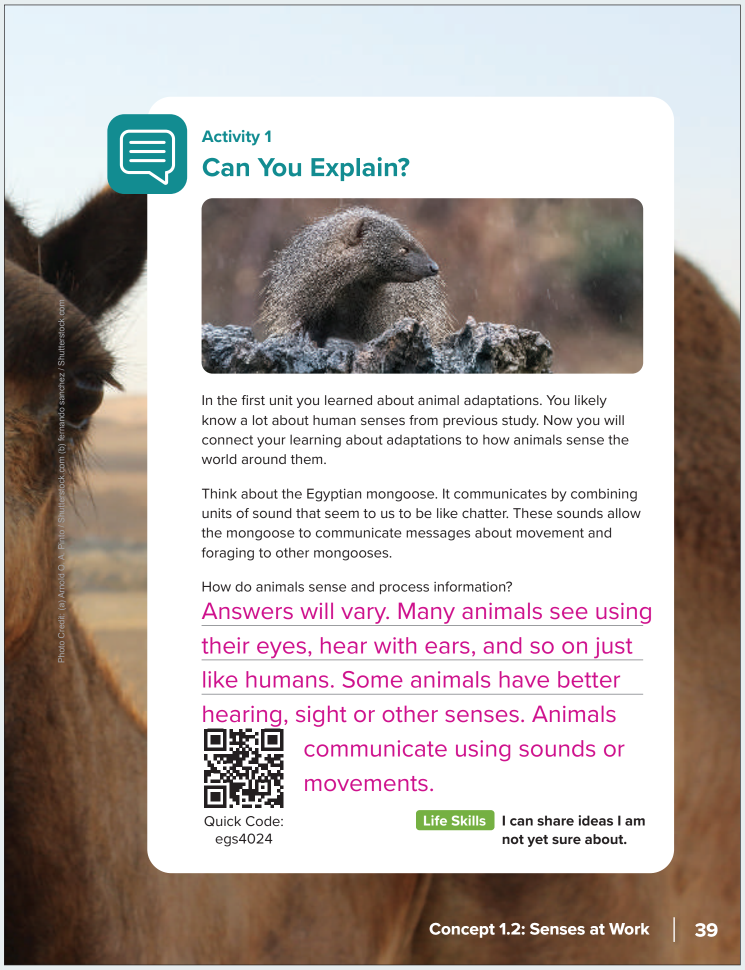

Activity 1
Can You Explain?

In the first unit you learned about animal adaptations. You likely know a lot about human senses from previous study. Now you will connect your learning about adaptations to how animals sense the world around them.

Think about the Egyptian mongoose. It communicates by combining units of sound that seem to us to be like chatter. These sounds allow the mongoose to communicate messages about movement and foraging to other mongooses.

How do animals sense and process information?

Answers will vary. Many animals see using their eyes, hear with ears, and so on just like humans. Some animals have better hearing, sight or other senses. Animals communicate using sounds or movements.

Quick Code: egs4024

Life Skills I can share ideas I am not yet sure about.

Concept 1.2: Senses at Work | 39

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Quick Code:
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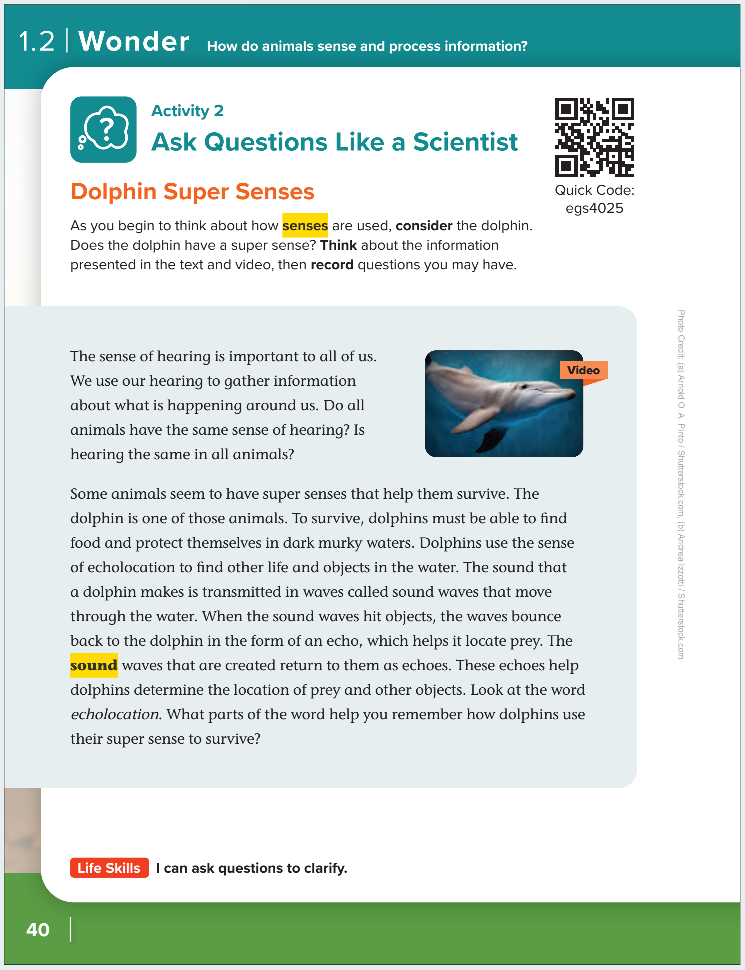

1.2 | **Wonder** How do animals sense and process information?

Activity 2
Ask Questions Like a Scientist

Quick Code: egs4025

Dolphin Super Senses

As you begin to think about how **senses** are used, **consider** the dolphin. Does the dolphin have a super sense? **Think** about the information presented in the text and video, then **record** questions you may have.

The sense of hearing is important to all of us. We use our hearing to gather information about what is happening around us. Do all animals have the same sense of hearing? Is hearing the same in all animals?

Video

Some animals seem to have super senses that help them survive. The dolphin is one of those animals. To survive, dolphins must be able to find food and protect themselves in dark murky waters. Dolphins use the sense of echolocation to find other life and objects in the water. The sound that a dolphin makes is transmitted in waves called sound waves that move through the water. When the sound waves hit objects, the waves bounce back to the dolphin in the form of an echo, which helps it locate prey. The **sound** waves that are created return to them as echoes. These echoes help dolphins determine the location of prey and other objects. Look at the word *echolocation*. What parts of the word help you remember how dolphins use their super sense to survive?

Life Skills I can ask questions to clarify.

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Photo Credit: Andrea Izzotti / Shutterstock.com

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Activity 2
Ask Questions Like a Scientist
Dolphin Super Senses

Quick Code:
egst4025

Lesson 1, *continued*

Investigative Phenomenon

Activity 2
Ask Questions Like a Scientist

15 min

Dolphin Super Senses

Purpose

The Investigative Phenomenon sparks curiosity in students as they begin to consider the role of animal senses. This activity asks students to share questions about unique super senses that some animals have developed to survive.

Instructional Focus

In this activity, students ask questions that can be investigated about sensory organs and the nervous system.

Life Skills **Negotiation**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the video, text has been provided to support learning.

Students have investigated some of the adaptations of systems that enable animals and plants to survive. In this concept, they focus on the role of sense organs and the rest of the nervous system in ensuring the survival of organisms.

To stimulate student thinking about senses, ask them to consider how fictional superhero super senses compare to real and possible senses.

To help students to understand the concept of how sound vibrations travel through the air, if time permits, consider conducting the following demonstration. Gather two metal cans that have been opened and emptied of the contents. Cover the open end of one

Lesson 1, *continued*

with plastic wrap. Secure the wrap, so that it is stretched tightly across the opening, with a rubber band. Sprinkle salt across the surface of the plastic. Hold the other can above the plastic wrap, open side down. Tap on the bottom of the can with a pencil. Students should see the salt "dance" on the plastic beneath. Use the demonstration to facilitate a class discussion about vibrations and how sound travels through the air in invisible waves.

Use the resources in Wonder to connect the idea that some organisms really have super senses (which can be just as strange as fictional ones) that are essential adaptations to their environment.

After reading the text and watching the video, encourage students to generate their own questions about senses based on what they read and observe. Questions should begin with words such as "What," "Why," and "When."

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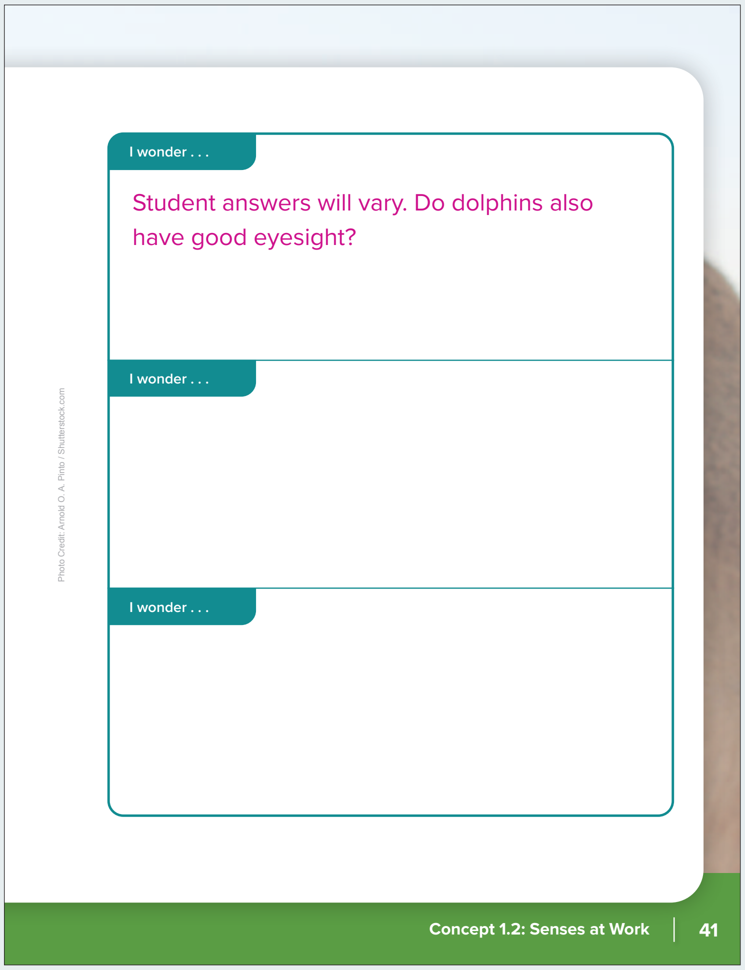

I wonder . . .

Student answers will vary. Do dolphins also have good eyesight?

I wonder . . .

I wonder . . .

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Concept 1.2: Senses at Work | 41

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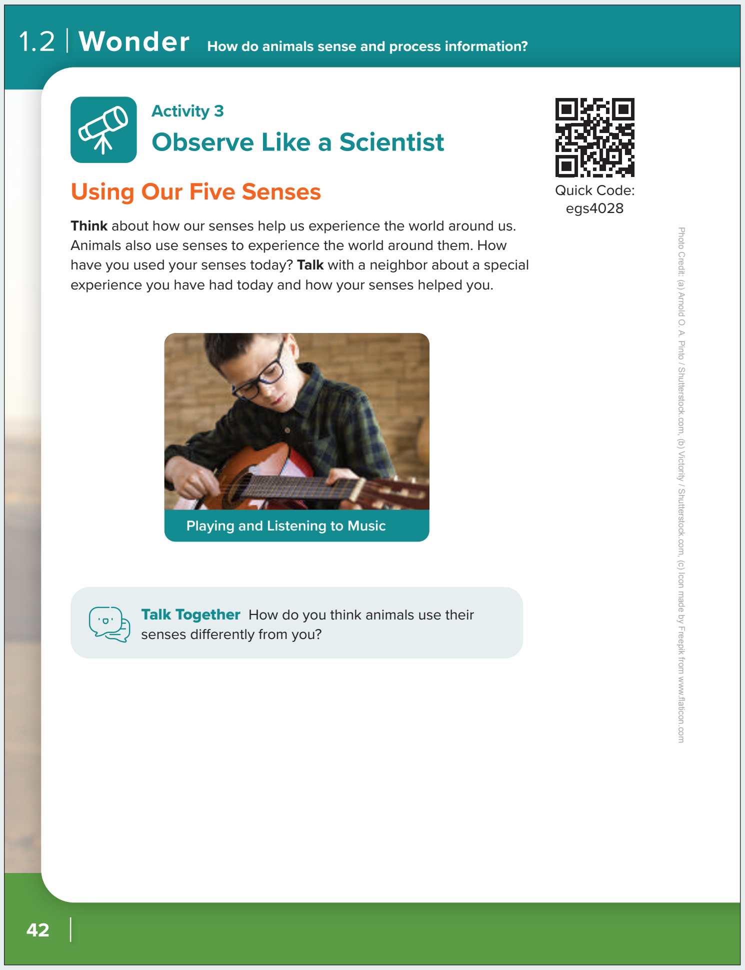

1.2 | **Wonder** How do animals sense and process information?

Activity 3

Observe Like a Scientist

Quick Code:
egs4028

Using Our Five Senses

Think about how our senses help us experience the world around us. Animals also use senses to experience the world around them. How have you used your senses today? **Talk** with a neighbor about a special experience you have had today and how your senses helped you.

Playing and Listening to Music

Talk Together How do you think animals use their senses differently from you?

Photo Credit: (a) Arnold O. A. Pinto / Shutterstock.com, (b) Victority / Shutterstock.com, (c) Icon made by Freepik from www.flaticon.com

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Photo Credit: Victority / Shutterstock.com

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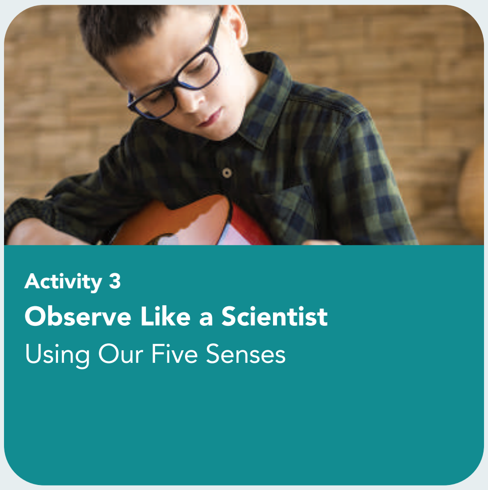

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Activity 3

Observe Like a Scientist

10 min

Using Our Five Senses

Purpose

In this activity, students are encouraged to extend thinking about senses to their own daily lives. Students make observations about how they use their own senses to understand the world around them.

Instructional Focus

In this activity, students explore patterns in how the five senses are used to gather and process information in an environment.

Strategy

Ask students to think about how they use their own senses in their daily lives. Encourage students to think about what they see, feel, hear, and so on. Invite a few students to share how senses help them understand the world around them.

ASK

- *How have your senses helped you at school today?*
  Student answers will vary.
- *Do you think some of your senses are more effective than others? Why or why not?*
  Student answers will vary.

Lesson 1, *continued*

Activity 4
Evaluate Like a Scientist

10 min

What Do You Already Know About Senses at Work?

Purpose

This formative assessment will allow students to demonstrate existing knowledge about animal senses and perception. At this point, fully formed scientific answers are less important than students' ability to provide examples to support reasoning.

Instructional Focus

In this activity, students use existing knowledge of animal senses and perception to demonstrate their understanding of how animals' senses help them survive. Then, they use existing knowledge of senses to demonstrate their understanding of sensory response processing.

Animal Perceptions

Strategy

The item Animal Perceptions provides a formative assessment of students' existing knowledge of the ways in which animals perceive the world. Be sure to clear up the common misconception that animals and humans can perceive the same stimuli. A class discussion about the results will enable you to get further pre-assessment information.

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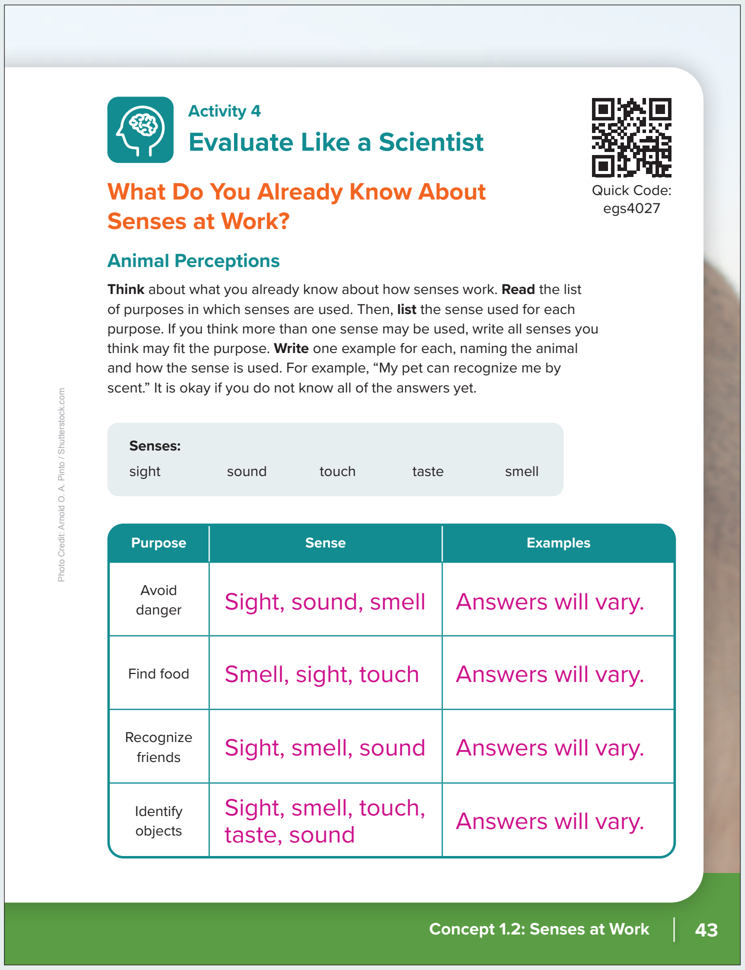

Activity 4

Evaluate Like a Scientist

What Do You Already Know About Senses at Work?

Quick Code: egs4027

Animal Perceptions

Think about what you already know about how senses work. **Read** the list of purposes in which senses are used. Then, **list** the sense used for each purpose. If you think more than one sense may be used, write all senses you think may fit the purpose. **Write** one example for each, naming the animal and how the sense is used. For example, "My pet can recognize me by scent." It is okay if you do not know all of the answers yet.

Senses:
sight sound touch taste smell

Purpose	Sense	Examples
Avoid danger	Sight, sound, smell	Answers will vary.
Find food	Smell, sight, touch	Answers will vary.
Recognize friends	Sight, smell, sound	Answers will vary.
Identify objects	Sight, smell, touch, taste, sound	Answers will vary.

Photo Credit: Arnold O. A. Pinto / Shutterstock.com

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Activity 4

Evaluate Like a Scientist

What Do You Already Know About Senses at Work?

Quick Code: egst4027

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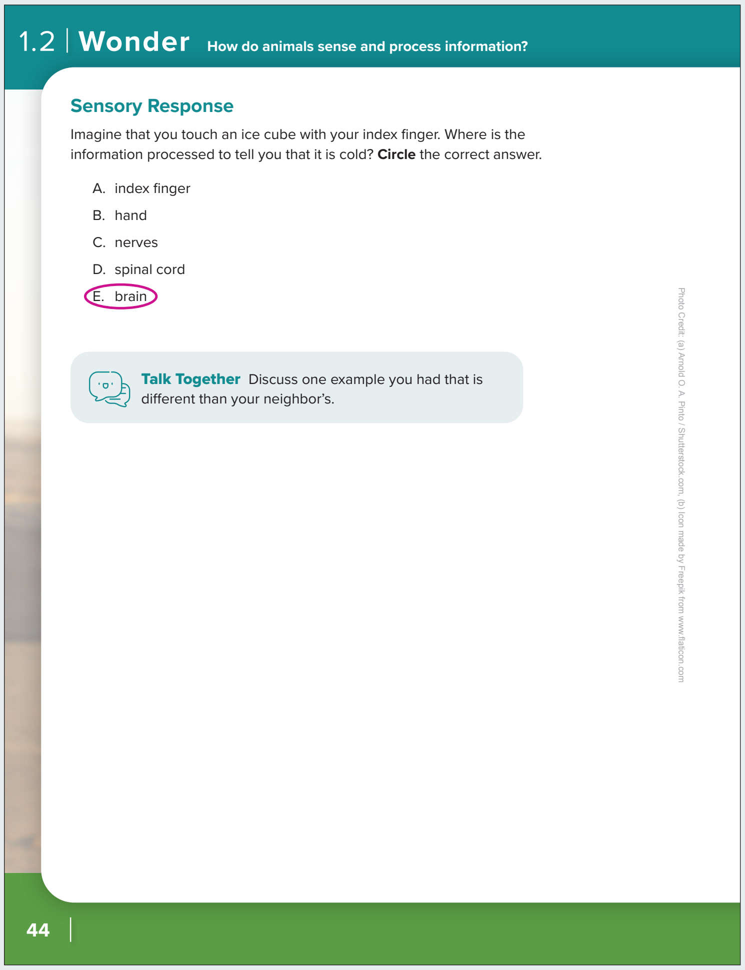

1.2 | **Wonder** **How do animals sense and process information?**

Sensory Response

Imagine that you touch an ice cube with your index finger. Where is the information processed to tell you that it is cold? **Circle** the correct answer.

A. index finger
B. hand
C. nerves
D. spinal cord
E. brain

Talk Together Discuss one example you had that is different than your neighbor's.

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Lesson 1, *continued*

Sensory Response

Strategy

The item Sensory Response provides a formative assessment of students' existing knowledge of sensory response processing. Prior to presenting students with the question, explain that though students have not yet discussed how sensory information is processed, they can use what they already know to predict an answer to the question.

Teacher Reflection

- What content do my students already know?
- What misconceptions do my students have at this point in the course?
- Are any of my students ready for extension at this point in the lesson?

Lesson 2

Activity 5
Observe Like a Scientist

25 min

Super Senses

Purpose

During the previous concept, students learned about how specific adaptations help animals in extreme climates survive. Now, using their own senses as a basis for understanding, students take a closer look at how specialized senses help animals find food and get around.

Instructional Focus

In this activity, students read a text and watch videos to find evidence to explain how the unique sensory abilities of some animals help them to hunt for food when the animals cannot rely on the sense of sight alone.

Life Skills **Critical Thinking**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Use the texts and videos to engage students with the super senses of various animals.

Ask students to describe how adaptations to super senses help different animals survive in their habitats.

Prepare students for reading the passages and watching the videos by asking them to describe briefly what they already know about snakes, bats, and owls. Encourage them to look at the images and make predictions about how these animals use their senses to help them survive.

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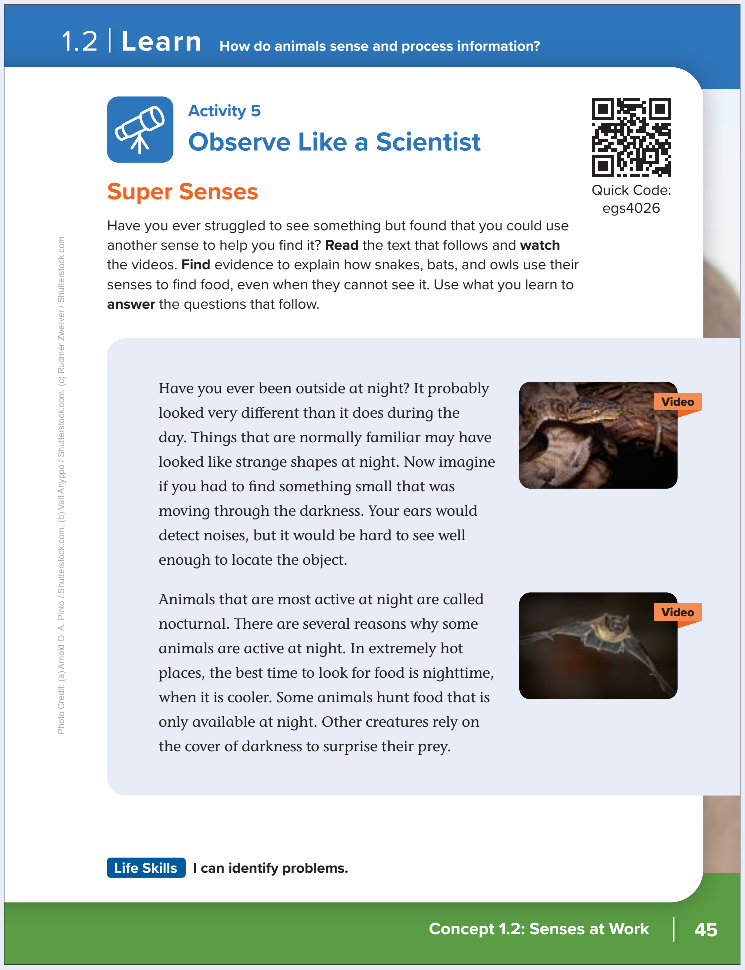

1.2 | Learn How do animals sense and process information?

Activity 5

Observe Like a Scientist

Quick Code: egs4026

Super Senses

Have you ever struggled to see something but found that you could use another sense to help you find it? **Read** the text that follows and **watch** the videos. **Find** evidence to explain how snakes, bats, and owls use their senses to find food, even when they cannot see it. Use what you learn to **answer** the questions that follow.

Have you ever been outside at night? It probably looked very different than it does during the day. Things that are normally familiar may have looked like strange shapes at night. Now imagine if you had to find something small that was moving through the darkness. Your ears would detect noises, but it would be hard to see well enough to locate the object.

Video

Animals that are most active at night are called nocturnal. There are several reasons why some animals are active at night. In extremely hot places, the best time to look for food is nighttime, when it is cooler. Some animals hunt food that is only available at night. Other creatures rely on the cover of darkness to surprise their prey.

Video

Life Skills I can identify problems.

Concept 1.2: Senses at Work | 45

Photo Credit: Valt Ahyppo / Shutterstock.com

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Activity 5
Observe Like a Scientist
Super Senses

Quick Code: egst4026

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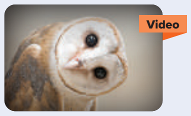
1.2 | **Learn** How do animals sense and process information?



How do these animals hunt without much available light? Super sensory adaptations allow these animals to navigate the darkness safely and find food sources. Snakes have the ability to sense heat using a specialized body part in their face. This means snakes can detect warm-blooded prey in complete darkness. Bats rely on echolocation. Like dolphins, bats bounce sounds off objects to find food and get around. Unlike dolphins, bats must hunt in the dark. Using the "echo" that returns, bats are able to find insects at night. Owls have both extraordinary sight and hearing. Bowl-shaped faces and specialized head feathers direct distant sounds directly into the owl's ears. Sometimes animals making noises are hidden in the grass or beneath the snow. Large eyes allow the owl to see tiny, far-away movements. The ability to turn their heads nearly all the way around lets owls search for prey in every direction.

Snakes use heat to hunt. Why would this special sense be useful to snakes?

Snakes are unable to see at night, so they use their sense of heat to find their prey.

How do bats catch gnats in the dark?

Bats are nocturnal and hunt for food at night. They can't see very well in the dark, so they use echolocation, or echoes, to help them hear where their food is.

How does the shape of an owl's head help it hear what it cannot see?

The owl's bowl-shaped face picks up distant sounds and amplifies them.

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Lesson 2, *continued*

Lead a discussion on the questions posed. Have students share answers with the class before writing individual answers. Encourage students to expand on their thinking by asking questions such as, *Can you say more about that? What do you mean by that? What specific examples from the videos support what you are saying?*

ASK

- *Snakes use heat to hunt. Why would this special sense be useful to snakes?* *Snakes are unable to see at night, so they use their sense of heat to find their prey.*
- *How do bats catch gnats in the dark?* *Bats are nocturnal and hunt for food at night. They can't see very well in the dark, so they use echolocation, or echoes, to help them hear where their food is.*
- *How does the shape of an owl's head help it hear what it cannot see?* *The owl's bowl-shaped face picks up distant sounds and amplifies them.*

Differentiation

ADVANCED LEARNERS

Challenge students to research why different animals may have a better sense of touch, smell, sight, hearing, or taste than humans.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- What would I organize differently next year?

Lesson 2, *continued*

How Do Animals Sense Their Environment?

Activity 6
Analyze Like a Scientist

15 min

Pizza and the Nervous System

Purpose

In this activity, students use the common experience of smelling pizza to explore how humans collect information through the senses and how the parts of the nervous system carry information to the brain.

Instructional Focus

In this activity, students explore how the senses work together with the nervous system to gather information in an environment.

Strategy

Prior to reading Pizza and the Nervous System, guide students to make a connection to the reading by asking them to imagine they are standing outside a kitchen or restaurant. If there were no signs telling them what was being served for lunch,

ASK *How could you sense what food is being prepared?*
You might be able to smell the food and recognize the scent.

Ask students to read the text on how the nose detects the smell of pizza. For extra literacy support, divide students into pairs to read the passage together and encourage them to identify words in the text that could be replaced by other words with similar meanings.

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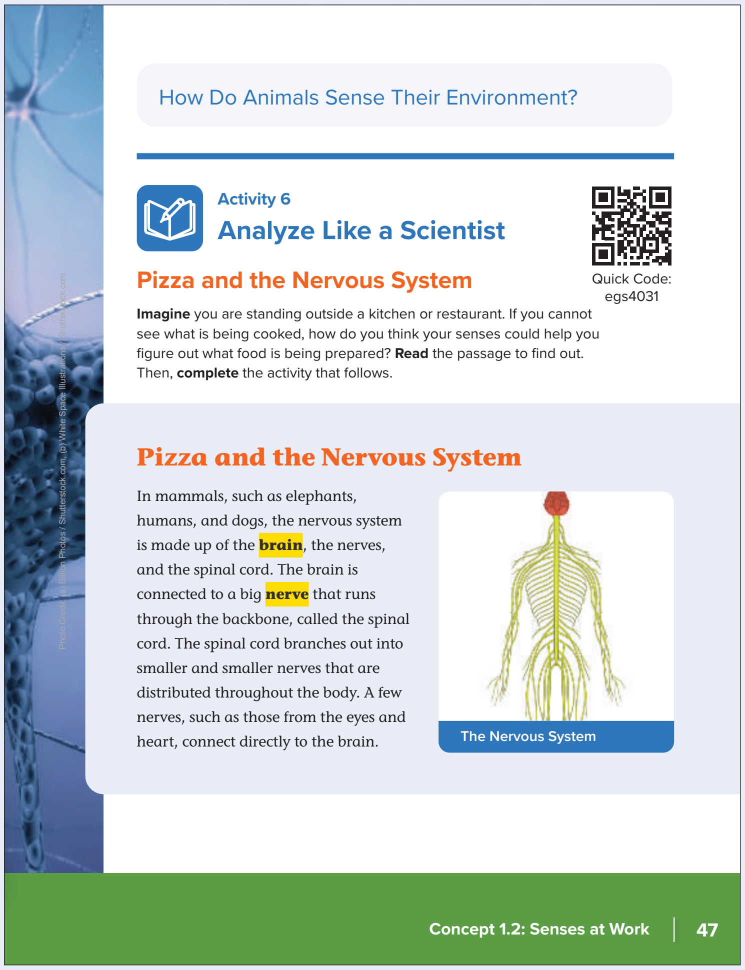

How Do Animals Sense Their Environment?

Activity 6
Analyze Like a Scientist

Quick Code: egs4031

Pizza and the Nervous System

Imagine you are standing outside a kitchen or restaurant. If you cannot see what is being cooked, how do you think your senses could help you figure out what food is being prepared? **Read** the passage to find out. Then, **complete** the activity that follows.

Pizza and the Nervous System

In mammals, such as elephants, humans, and dogs, the nervous system is made up of the **brain**, the nerves, and the spinal cord. The brain is connected to a big **nerve** that runs through the backbone, called the spinal cord. The spinal cord branches out into smaller and smaller nerves that are distributed throughout the body. A few nerves, such as those from the eyes and heart, connect directly to the brain.

The Nervous System

Concept 1.2: Senses at Work | 47

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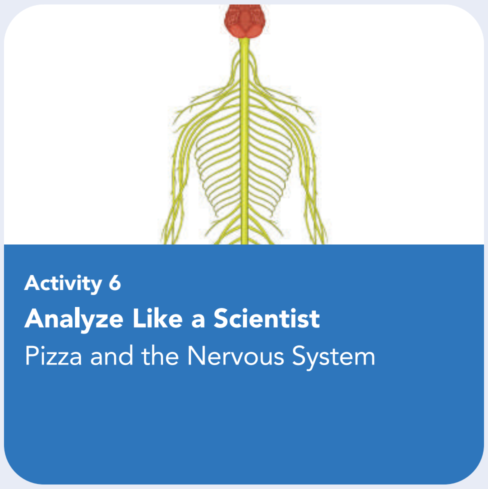

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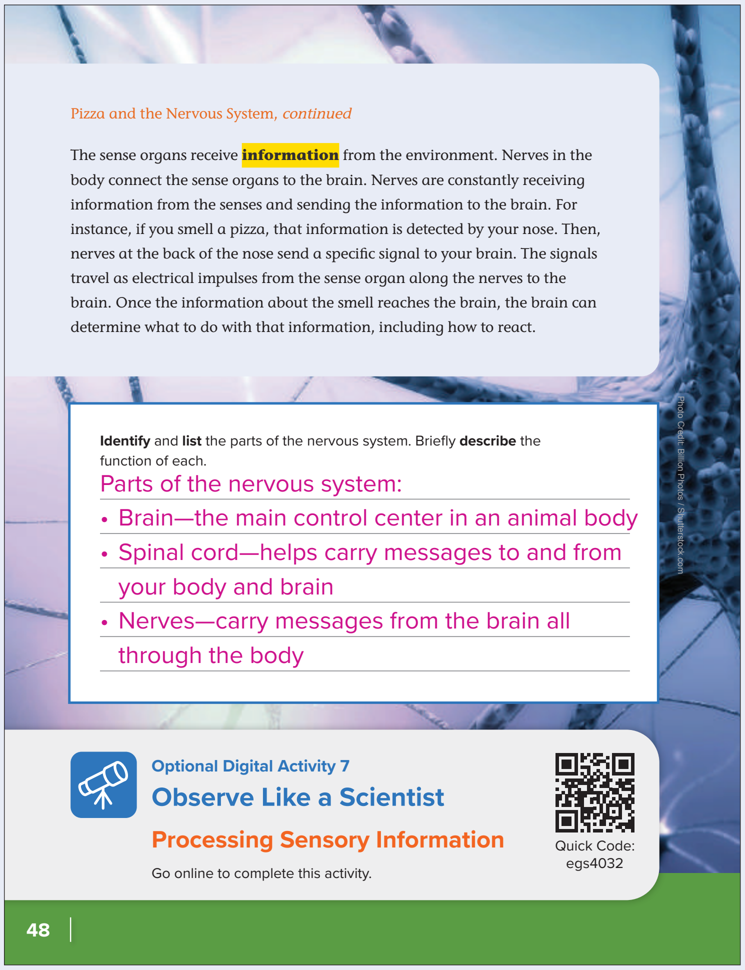

Pizza and the Nervous System, *continued*

The sense organs receive **information** from the environment. Nerves in the body connect the sense organs to the brain. Nerves are constantly receiving information from the senses and sending the information to the brain. For instance, if you smell a pizza, that information is detected by your nose. Then, nerves at the back of the nose send a specific signal to your brain. The signals travel as electrical impulses from the sense organ along the nerves to the brain. Once the information about the smell reaches the brain, the brain can determine what to do with that information, including how to react.

Identify and **list** the parts of the nervous system. Briefly **describe** the function of each.

Parts of the nervous system:

- Brain—the main control center in an animal body
- Spinal cord—helps carry messages to and from your body and brain
- Nerves—carry messages from the brain all through the body

Optional Digital Activity 7

Observe Like a Scientist

Processing Sensory Information

Go online to complete this activity.

Quick Code: egs4032

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Lesson 2, *continued*

Next, instruct students to make a list of the parts of the nervous system.

ASK

- *What does the brain do with the information it receives from the nose?* *The brain identifies the signals from the nose.*
- *What role does memory play in responding to the smell of the pizza?* *The memory signals that the smell of pizza is associated with food.*

Differentiation

APPROACHING LEARNERS

Ask students to draw a model of the body, labeling parts that are involved in the senses. Encourage students to use vocabulary used in the lesson, such as *brain, ear, heart, nerve,* and *tongue*.

MISCONCEPTION

Some students may think that senses work on their own, independent of other parts of the nervous system. Indeed, the senses are part of the nervous system, which in turn is integrated and works with other systems of the body. For instance, when a person smells food, the information from the odor is sent to the brain, and then the brain determines how to react to the smell.

Optional Digital Activity 7

Observe Like a Scientist

15 min

Processing Sensory Information

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4032

Lesson 3

How Can Different Parts of the Body Work Together as a System?

Activity 8
Evaluate Like a Scientist

45 min

Sensing the Environment

Purpose

In this activity, students build upon what they have learned about how human body parts work in systems to understand how adaptations and the nervous system partner to help animals survive.

Instructional Focus

In this activity, students look for evidence to explain how physical adaptations, specialized sensory systems, and the nervous system work together to help the jerboa survive.

Life Skills **Critical Thinking**

Strategy

Prior to reading Jumping Jerboa, ask students if they are familiar with the jerboa or if they have ever seen one in the desert. While looking at the photograph of the jerboa, ask students to consider which physical traits might make the jerboa well-adapted to survival in the extreme conditions of the desert.

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Pages 49–50

How Can Different Parts of the Body Work Together As a System?

Activity 8

Evaluate Like a Scientist

Quick Code: egs4033

Sensing the Environment

Read the following passage to learn more about an extra-small animal with extra-large ears, the Egyptian jerboa. **Consider** the different systems that work together to help this animal stay alive. **Think** about what you know about the human nervous system's role in responding to danger and how this compares to the jerboa reaction. **Record** your thoughts and findings.

Jumping Jerboa

Evening in the desert means it is time for many animals to wake up and hunt. Just like people use their senses to find and enjoy food, so do animals. For some creatures, searching for food can also mean becoming someone's dinner. Luckily, keen senses and well-adapted body parts work together to help animals survive.

The Egyptian Jerboa

Concept 1.2: Senses at Work | 49

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Activity 8
Evaluate Like a Scientist
Sensing the Environment

Quick Code:
egst4033

Photo Credit: Michal Sloviak / Shutterstock.com

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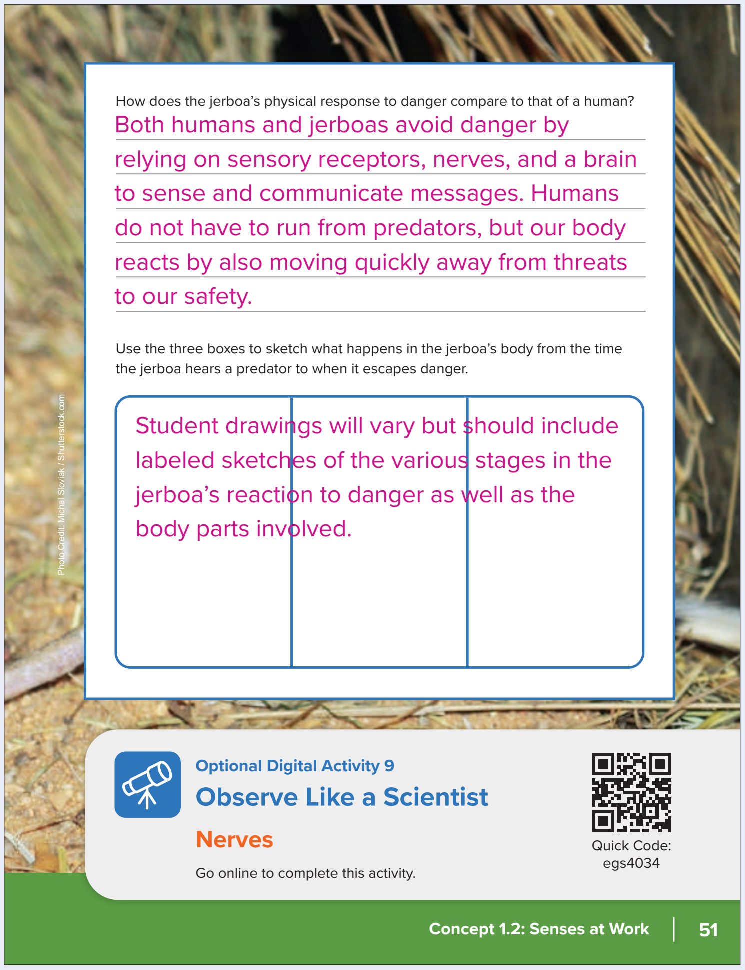

How does the jerboa's physical response to danger compare to that of a human?

Both humans and jerboas avoid danger by relying on sensory receptors, nerves, and a brain to sense and communicate messages. Humans do not have to run from predators, but our body reacts by also moving quickly away from threats to our safety.

Use the three boxes to sketch what happens in the jerboa's body from the time the jerboa hears a predator to when it escapes danger.

Student drawings will vary but should include labeled sketches of the various stages in the jerboa's reaction to danger as well as the body parts involved.

Optional Digital Activity 9

Observe Like a Scientist

Nerves

Go online to complete this activity.

Quick Code: egs4034

Concept 1.2: Senses at Work | 51

Lesson 3, *continued*

ASK

- *Which sense do you think the jerboa relies upon most to help it to sense danger?*
  Since the jerboa's eyes are small and the ears are big, maybe the jerboa primarily uses its sense of hearing.
- *Knowing what you know about how the human body works in systems to avoid danger, what can you predict about how the jerboa stays safe?*
  We know that the brain sends messages to different parts of the body so that we can react to danger quickly. Maybe the nervous system of the jerboa works in the same way.

Pair students with a reading partner. Ask pairs to read the passage together and then discuss the first student response item.

Once students have had a chance to discuss with their partner, provide students with time to individually complete the student responses.

If time allows, ask students to share their sketches with the class.

Optional Digital Activity 9

Observe Like a Scientist

20 min

Nerves

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4034

Lesson 4

Activity 10
Investigate Like a Scientist

45 min

Hands-On Investigation: Reaction Time

Purpose

This activity will help students synthesize what they have learned about the function of the nervous system in different animals and the role that senses play in survival. Students investigate their own senses, which helps provide context for how other animals rely on sight, hearing, and quick reaction times in order to stay alive.

Instructional Focus

In this activity, students carry out an investigation about reaction time in response to auditory versus visual stimuli.

Life Skills **Collaboration**

Materials List (per group)

- Meterstick
- Calculator
- Chair

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Use caution when standing on a chair.
- Follow proper disposal and cleaning procedures after the lab.
- Tie back long hair.
- Do not eat or drink anything in the lab.

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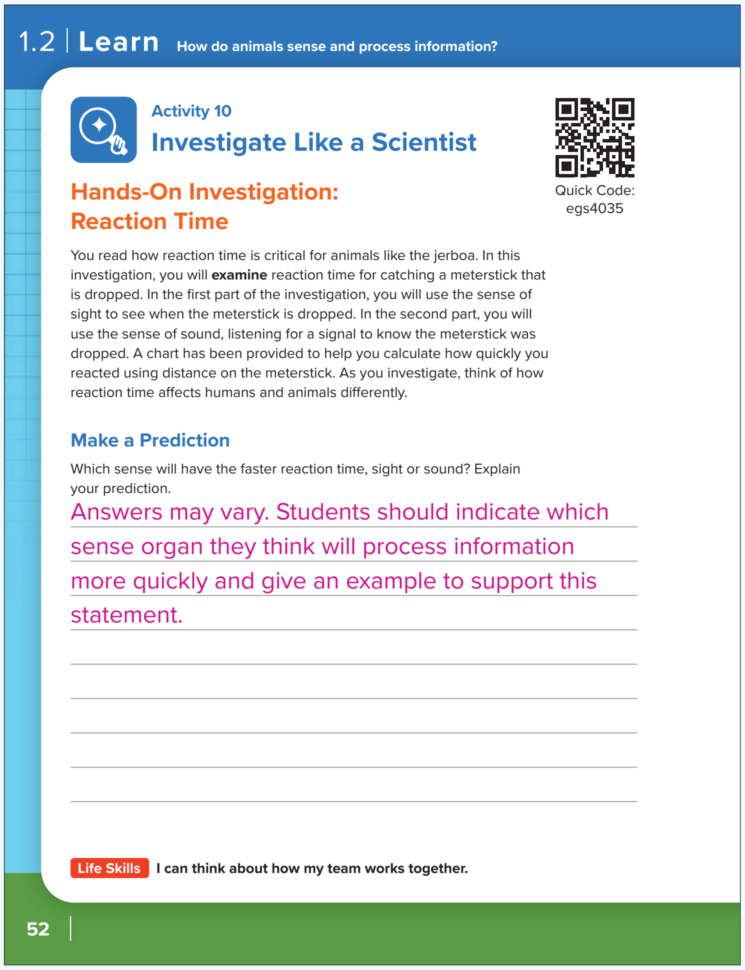
1.2 | **Learn** How do animals sense and process information?

Activity 10

Investigate Like a Scientist

Quick Code: egs4035

Hands-On Investigation: Reaction Time

You read how reaction time is critical for animals like the jerboa. In this investigation, you will **examine** reaction time for catching a meterstick that is dropped. In the first part of the investigation, you will use the sense of sight to see when the meterstick is dropped. In the second part, you will use the sense of sound, listening for a signal to know the meterstick was dropped. A chart has been provided to help you calculate how quickly you reacted using distance on the meterstick. As you investigate, think of how reaction time affects humans and animals differently.

Make a Prediction

Which sense will have the faster reaction time, sight or sound? Explain your prediction.

Answers may vary. Students should indicate which sense organ they think will process information more quickly and give an example to support this statement.

Life Skills I can think about how my team works together.

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DIGITAL

Activity 10

Investigate Like a Scientist

Hands-On Investigation: Reaction Time

Quick Code: egst4035

Lesson 4, *continued*

Activity Activator: Make a Prediction

Students will compare visual and auditory reaction times by measuring how quickly they catch a meterstick.

Introduce students to the concept of reaction time. Have students turn to a partner and discuss the following situation: In races such as swim meets, it is important for the people timing the event to have accurate times. There are two ways they tell the swimmers to begin the race: a buzzer sounds and a light flashes. Timers are told to start their watches when they see the light flash rather than when they hear the buzzer. Why do you think this is so? Explain that the reaction time is how fast it takes your body to receive the input from the environment and then process a reaction. In this case, reaction time is how quickly it takes for timers to see the light and start the stopwatch. Today, students will conduct an investigation to see if the reaction time is quicker for visual or for auditory stimuli.

Have students predict which sense will have the faster reaction time, sight or sound. Students should record their predictions.

Teacher Preparation:

Gather materials in advance of students performing the lab.

Before explaining the procedures to students, challenge them to design a way to compare reaction time to a visual stimulus with reaction time to an auditory stimulus. Guide students with questions such as:

- *How can we use this meterstick to measure reaction time?*
- *What visual clues could we use?*
- *What auditory clues (sound) could we use?*

Lesson 4, *continued*

Activity Procedure: What Will You Do?

1. Assign students to groups of 2 or 3. Distribute the materials to each group.
2. Model for students how to measure the reaction time. One student should stand carefully on a chair, holding the top of the meterstick between two fingers. The meterstick should be oriented with the zero at the bottom. The second student should stand across from this student, holding his or her hand around the bottom of the meterstick, as close to the zero mark as possible but not touching it. At a random time, the person holding the meterstick releases it, and the other person tries to grasp the meterstick as quickly as possible. The students should then record the number of centimeters that the meterstick fell before being caught.
3. Have each student conduct the activity at least three times and record the measurements in the Reaction Time Data Table. Students should circle the median distance, or the middle number when all three trial distances are listed in ascending order.
4. Students may be unable to capture reaction times precisely and accurately using standard stopwatches. Therefore, to help students approximate their reaction times, a table has been provided for reference so that students can easily convert the median distance that the ruler traveled into their reaction time. (Note: These reaction times are calculated based on the rate of gravitational acceleration on Earth. All falling objects accelerate toward the ground at a rate of about 9.8 meters per second.) Students do not need to understand gravity, the way the conversion chart was calculated, or how to work with decimals in this activity. Support students in finding the median number by encouraging them to focus on and compare the digits, not the decimal points.

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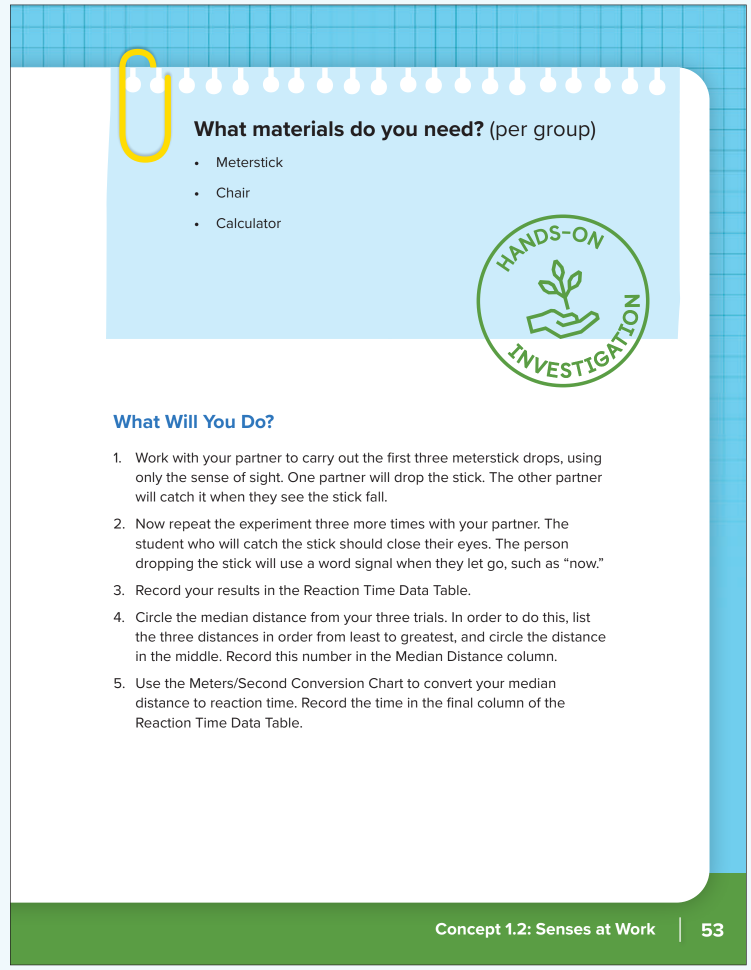

What materials do you need? (per group)

- Meterstick
- Chair
- Calculator

What Will You Do?

1. Work with your partner to carry out the first three meterstick drops, using only the sense of sight. One partner will drop the stick. The other partner will catch it when they see the stick fall.
2. Now repeat the experiment three more times with your partner. The student who will catch the stick should close their eyes. The person dropping the stick will use a word signal when they let go, such as "now."
3. Record your results in the Reaction Time Data Table.
4. Circle the median distance from your three trials. In order to do this, list the three distances in order from least to greatest, and circle the distance in the middle. Record this number in the Median Distance column.
5. Use the Meters/Second Conversion Chart to convert your median distance to reaction time. Record the time in the final column of the Reaction Time Data Table.

Concept 1.2: Senses at Work | 53

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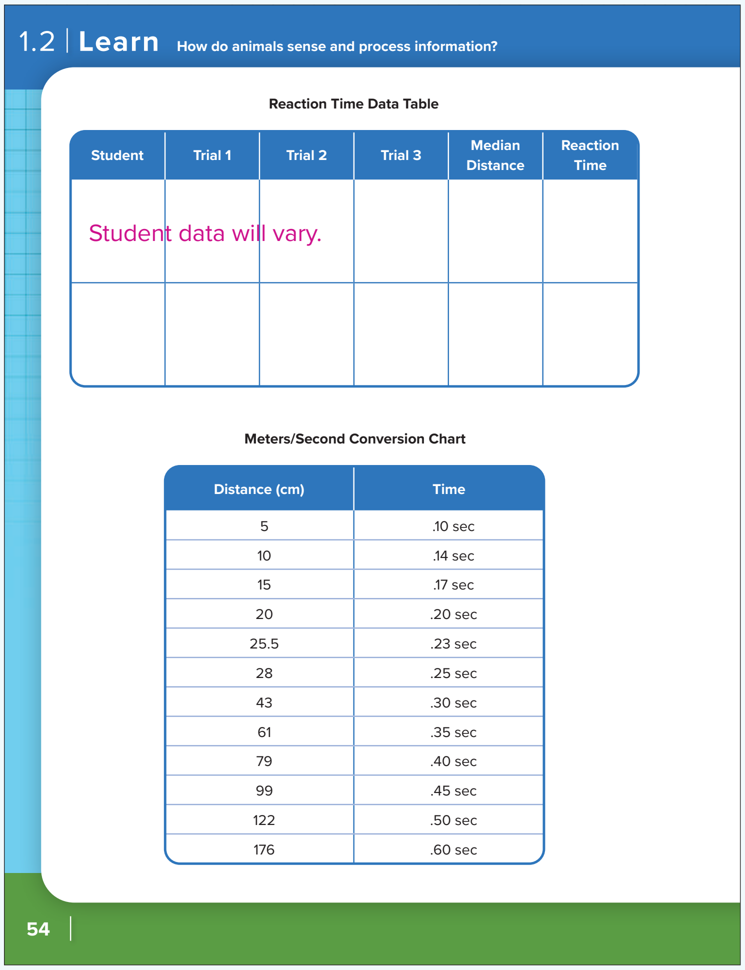

1.2 | **Learn** How do animals sense and process information?

Reaction Time Data Table

Student	Trial 1	Trial 2	Trial 3	Median Distance	Reaction Time
Student data will vary.					

Meters/Second Conversion Chart

Distance (cm)	Time
5	.10 sec
10	.14 sec
15	.17 sec
20	.20 sec
25.5	.23 sec
28	.25 sec
43	.30 sec
61	.35 sec
79	.40 sec
99	.45 sec
122	.50 sec
176	.60 sec

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Lesson 4, *continued*

Meters/Second Conversion Chart

Distance (cm)	Time
5	.10 sec
10	.14 sec
15	.17 sec
20	.20 sec
25.5	.23 sec
28	.25 sec
43	.30 sec
61	.35 sec
79	.40 sec
99	.45 sec
122	.50 sec
176	.60 sec

5. Have the students repeat the investigation. However, this time the student catching should close his or her eyes. The person dropping the meterstick should say a word, such as "drop" or "now," as a signal for the student to catch the meterstick. Again, have the students record the reaction time for three trials.

6. Allow groups to switch roles so that everyone has a chance to test their reaction time.

7. Discuss the results with the students.

ASK *Which resulted in the quicker reaction time: auditory or visual signals? How was the information received and processed in each of these examples?*
Student answers will vary according to their results. Our eyes and ears received information, nerves passed along the information to the brain for processing, then the brain sent the message to our hand to catch the stick.

8. Instruct students to complete the Think About the Activity questions.

Lesson 4, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *How was the information processed in each part of the investigation?*
  In the first part, my eyes saw the meterstick drop and sent signals to my brain through nerves. The brain processed the information and sent messages to the muscles in my hand to grasp the stick. In the second part, my ears received the signal and sent the message to my brain to process the information and respond.
- *Was there a difference in reaction time between seeing the meterstick drop and being told it was dropped? Use what you have learned to explain your results.*
  Possible response: I was able to catch the meterstick faster when I saw it drop. My brain was able to process what my eyes saw faster than I was able to process what I heard.
- *Why was it important to do multiple trials for each person?*
  The person may have been distracted in one trial. Multiple trials improve accuracy.
- *What are two examples of when reaction time is important in the world around us?*
  Possible responses: Seeing a red light and pressing the brakes on a car, hearing a fire alarm and lining up for a fire drill, feeling a hot object and dropping it.

Differentiation

ADVANCED LEARNERS

Challenge students to research different types of reflexes. Why does a doctor test reflexes? What does it tell the doctor?

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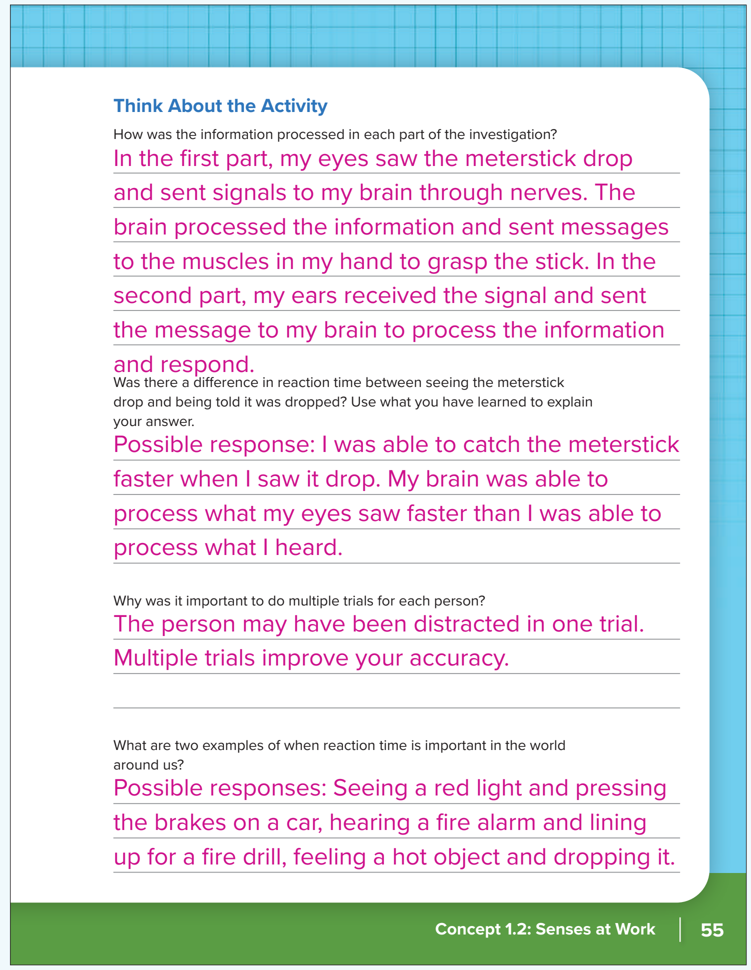

Think About the Activity

How was the information processed in each part of the investigation?

In the first part, my eyes saw the meterstick drop and sent signals to my brain through nerves. The brain processed the information and sent messages to the muscles in my hand to grasp the stick. In the second part, my ears received the signal and sent the message to my brain to process the information and respond.

Was there a difference in reaction time between seeing the meterstick drop and being told it was dropped? Use what you have learned to explain your answer.

Possible response: I was able to catch the meterstick faster when I saw it drop. My brain was able to process what my eyes saw faster than I was able to process what I heard.

Why was it important to do multiple trials for each person?

The person may have been distracted in one trial. Multiple trials improve your accuracy.

What are two examples of when reaction time is important in the world around us?

Possible responses: Seeing a red light and pressing the brakes on a car, hearing a fire alarm and lining up for a fire drill, feeling a hot object and dropping it.

Concept 1.2: Senses at Work | 55

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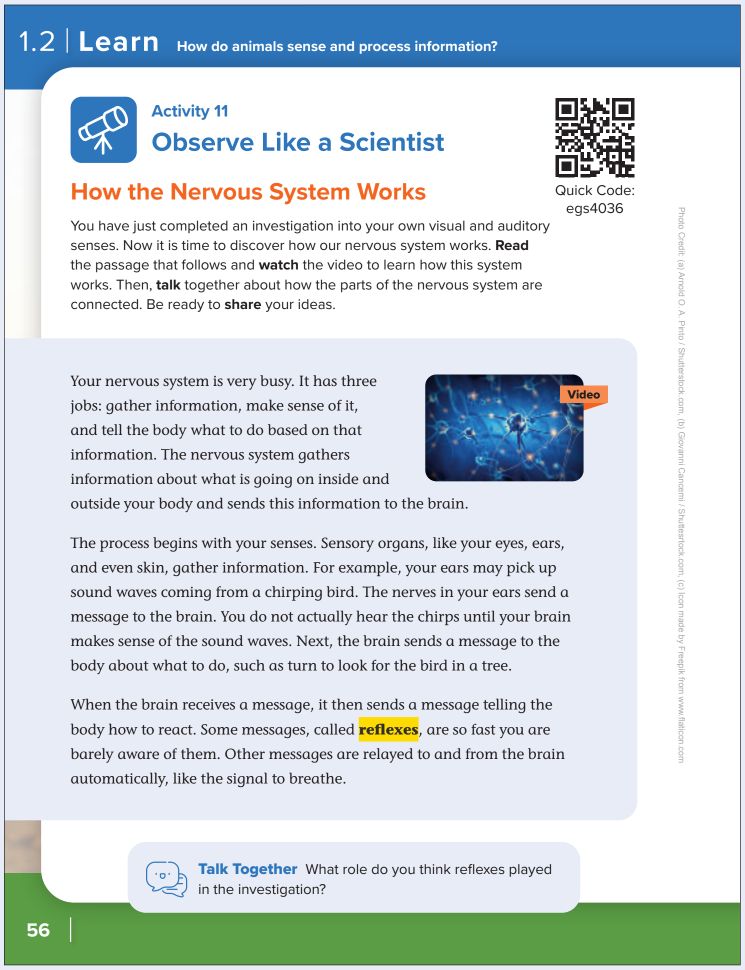

1.2 | **Learn** How do animals sense and process information?

Activity 11
Observe Like a Scientist

Quick Code:
egs4036

How the Nervous System Works

You have just completed an investigation into your own visual and auditory senses. Now it is time to discover how our nervous system works. **Read** the passage that follows and **watch** the video to learn how this system works. Then, **talk** together about how the parts of the nervous system are connected. Be ready to **share** your ideas.

Video

Your nervous system is very busy. It has three jobs: gather information, make sense of it, and tell the body what to do based on that information. The nervous system gathers information about what is going on inside and outside your body and sends this information to the brain.

The process begins with your senses. Sensory organs, like your eyes, ears, and even skin, gather information. For example, your ears may pick up sound waves coming from a chirping bird. The nerves in your ears send a message to the brain. You do not actually hear the chirps until your brain makes sense of the sound waves. Next, the brain sends a message to the body about what to do, such as turn to look for the bird in a tree.

When the brain receives a message, it then sends a message telling the body how to react. Some messages, called **reflexes**, are so fast you are barely aware of them. Other messages are relayed to and from the brain automatically, like the signal to breathe.

Talk Together What role do you think reflexes played in the investigation?

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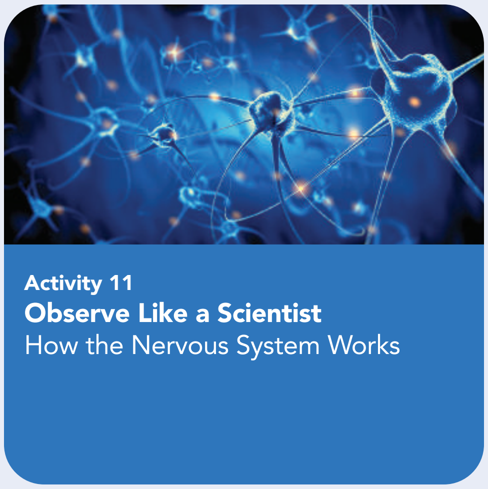

Quick Code:
egst4036

Lesson 5

Activity 11
Observe Like a Scientist

25 min

How the Nervous System Works

Purpose

In this activity, students combine what they know about sensory and motor input to describe how parts of the nervous system work together.

Instructional Focus

In this activity, students engage in argument from evidence to describe how parts of the nervous system are connected.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the video, text has been provided to support learning. Encourage students to think about what they learned in the previous Hands-On Investigation as they watch the video *How the Nervous System Works*.

- First, write the terms *sensory input* and *motor input* on the board. Tell students to look for the meaning of this vocabulary in the video.
- After reading the text and watching the video, discuss what students have learned about how senses and nerves work together to send messages throughout the body.

ASK *How are the components of the nervous system connected?*
The nervous system is connected by nerves that transmit messages around the body.

MISCONCEPTION
Some students may think that all actions are voluntary, or controlled by us. This is not the case. Some actions, such as the beating of our hearts, happen without us thinking about them. Reflexes are also involuntary.

Lesson 5, *continued*

Activity 12
Evaluate Like a Scientist

20 min

Describing the Nervous System

Purpose

Students previously discovered how the parts of the nervous system are connected. In this formative assessment, students explain their current understandings of the role of the nervous system and its component parts.

Instructional Focus

In this activity, students explain how components of the nervous system work together to carry out functions that the individual parts cannot.

Life Skills **Problem Solving**

The Nervous System

Strategy

Use the item The Nervous System to determine if students know the parts of the nervous system.

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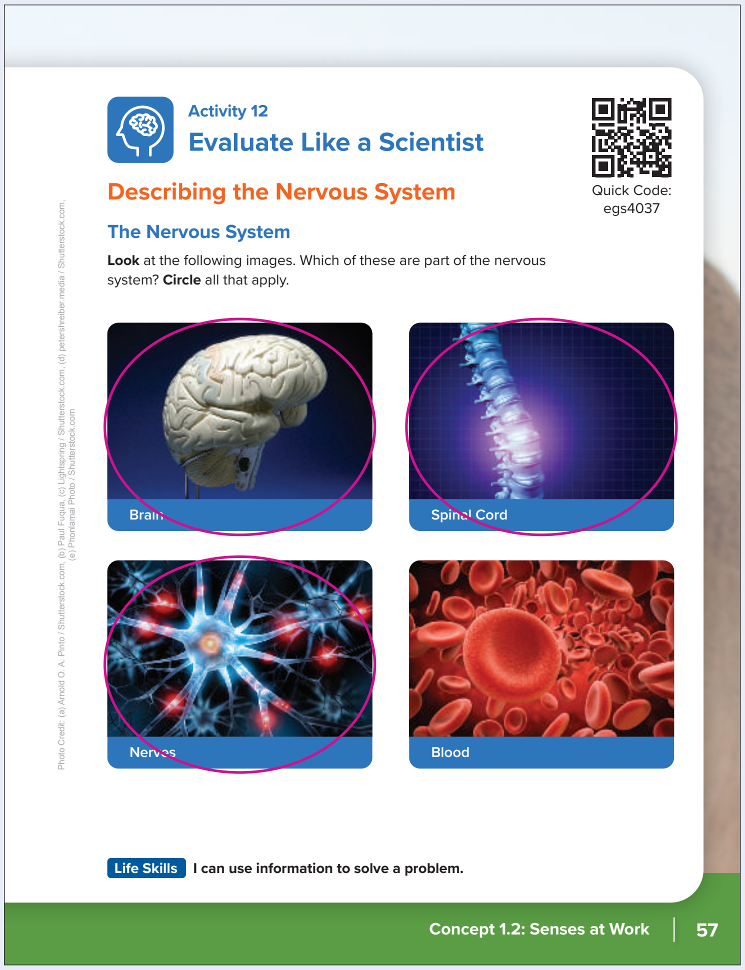
Activity 12
Evaluate Like a Scientist
Describing the Nervous System
Quick Code: egs4037
The Nervous System
Look at the following images. Which of these are part of the nervous system? **Circle** all that apply.
Brain
Spinal Cord
Nerves
Blood
Life Skills I can use information to solve a problem.
Concept 1.2: Senses at Work | 57

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Activity 12
Evaluate Like a Scientist
Describing the Nervous System

Quick Code:
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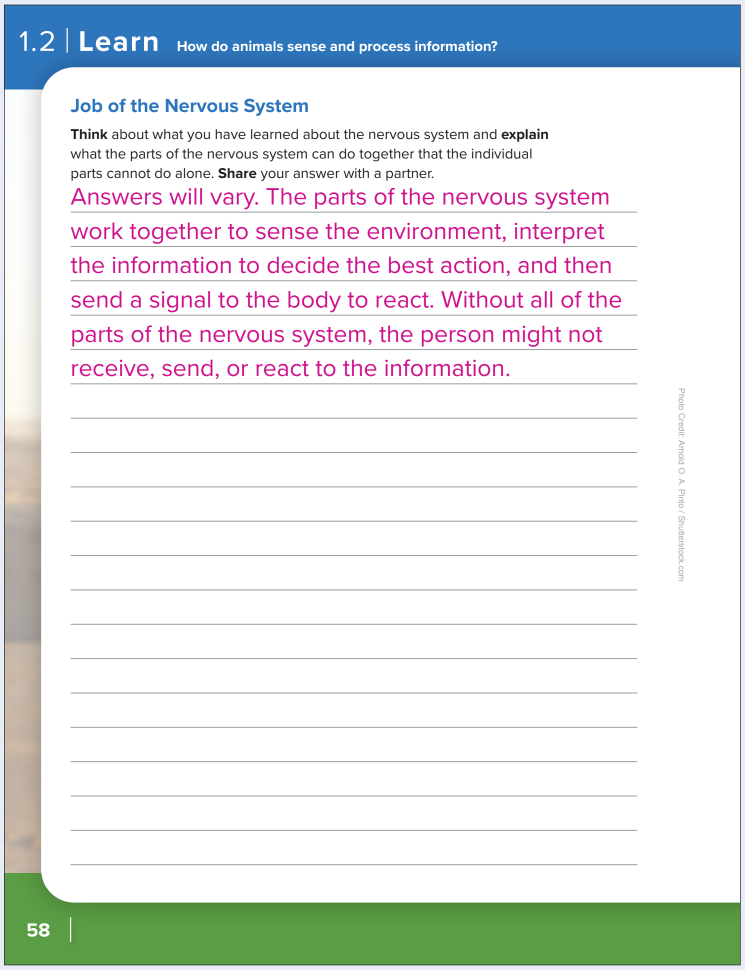

1.2 | **Learn** How do animals sense and process information?

Job of the Nervous System

Think about what you have learned about the nervous system and **explain** what the parts of the nervous system can do together that the individual parts cannot do alone. **Share** your answer with a partner.

Answers will vary. The parts of the nervous system work together to sense the environment, interpret the information to decide the best action, and then send a signal to the body to react. Without all of the parts of the nervous system, the person might not receive, send, or react to the information.

Photo Credit: Arnold O. A. Pinto / Shutterstock.com

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Lesson 5, *continued*

Job of the Nervous System

Strategy

The item Job of the Nervous System will allow you to assess students' ability to summarize the role the nervous system plays. Students may complete this individually or in pairs.

Lesson 5, *continued*

Describe the Nervous System

Strategy

In the item Describe the Nervous System, instruct students to select the correct terms in each sentence.

Differentiation

APPROACHING LEARNERS

Provide students with a diagram of the body with the parts labeled. Have students match each of the five senses with the part of the body that is involved.

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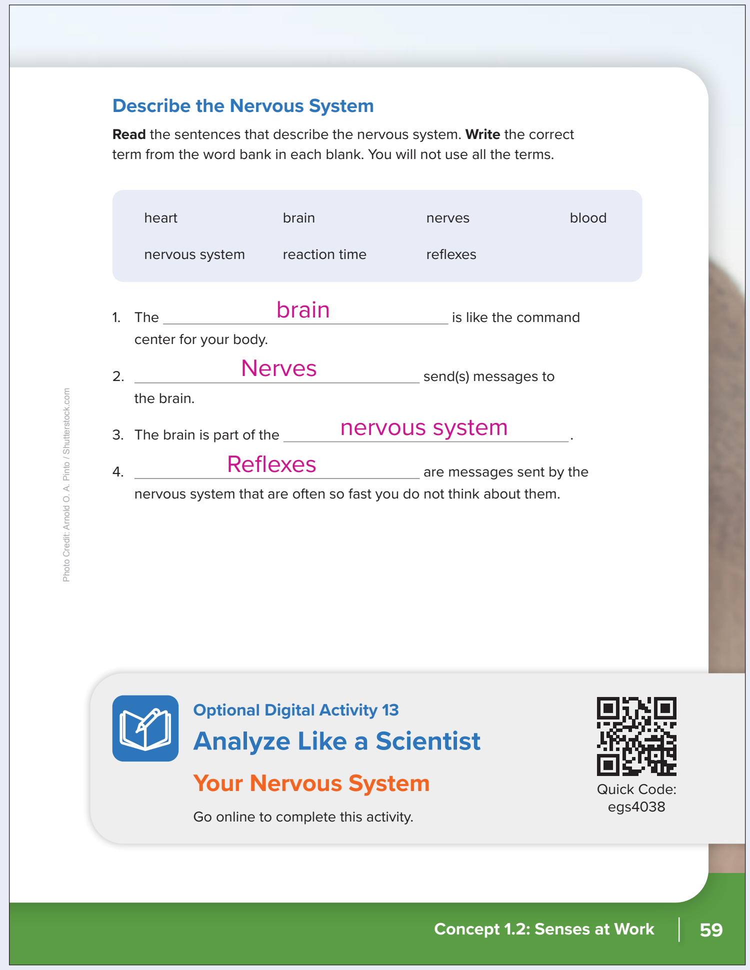

Describe the Nervous System

Read the sentences that describe the nervous system. **Write** the correct term from the word bank in each blank. You will not use all the terms.

heart	brain	nerves	blood
nervous system	reaction time	reflexes	

1. The ____brain____ is like the command center for your body.
2. ____Nerves____ send(s) messages to the brain.
3. The brain is part of the ____nervous system____.
4. ____Reflexes____ are messages sent by the nervous system that are often so fast you do not think about them.

Photo Credit: Arnold O. A. Pinto / Shutterstock.com

Optional Digital Activity 13
Analyze Like a Scientist
Your Nervous System
Go online to complete this activity.
Quick Code: egs4038

Concept 1.2: Senses at Work | 59

Optional Digital Activity 13
Analyze Like a Scientist

20 min

Your Nervous System

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4038

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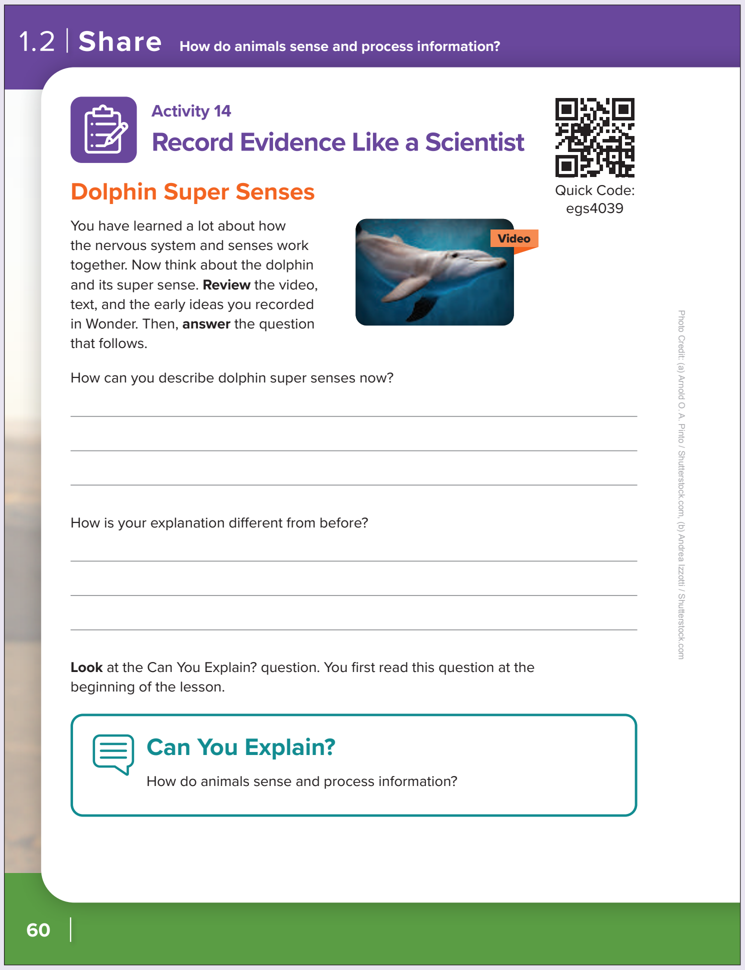

Activity 14

Record Evidence Like a Scientist

Quick Code: egs4039

Dolphin Super Senses

Video

You have learned a lot about how the nervous system and senses work together. Now think about the dolphin and its super sense. **Review** the video, text, and the early ideas you recorded in Wonder. Then, **answer** the question that follows.

How can you describe dolphin super senses now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?

How do animals sense and process information?

DIGITAL

Activity 14
Record Evidence Like a Scientist
Dolphin Super Senses

Quick Code:
egst4039

Lesson 6

Scientific Explanation

Activity 14
Record Evidence Like a Scientist

25 min

Dolphin Super Senses

Purpose

In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students construct explanations to communicate information about how animals use their nervous systems to retrieve and respond to information in the environment.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, students can return to the text provided in Wonder.

Guide students to review the text and video in the Investigative Phenomenon of Dolphin Super Senses and the Can You Explain? question. Ask students to use their experiences in Learn to consider how to explain the phenomenon. Once students have decided how best to describe the phenomenon, direct them to discuss their ideas with the class or a partner.

Once reasoning has been discussed, ask students to generate a scientific explanation to answer the Can You Explain? question. Students should write in full sentences, incorporating at least two pieces of evidence in support of their response.

Lesson 6, *continued*

Can You Explain?

How do animals sense and process information?

Students have written a scientific explanation in the prior concept and should be familiar with the claim-and-evidence framework. In later units, students will expand scientific explanations to include a claim, evidence, and reasoning. In this activity, you may want to review the following:

A **claim** is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with yes or no.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use information from text, video, or data that supports the claim. Leave out information that doesn't support the claim.

If needed, model writing a claims-and-evidence framework using a student question.

Sample student response:
Animals receive, transmit, and process sensory information through the nervous system. All animals have sense organs. In humans, our sense organs include the eyes, nose, ears, mouth and skin. When animals receive information from the environment, this information is transmitted to the brain through electrical impulses. When my nose smells pizza, a signal is sent to my brain, and then the brain sends signals to the rest of the body telling it how to react. The amount of time it takes to react can be different based on the stimulus. I could catch a meterstick faster using sight than with just hearing. Dolphins and bats use sound echolocation to find food. The sense organs allow animals to adapt and survive in their particular environment. If they didn't have these sense organs, they would not survive.

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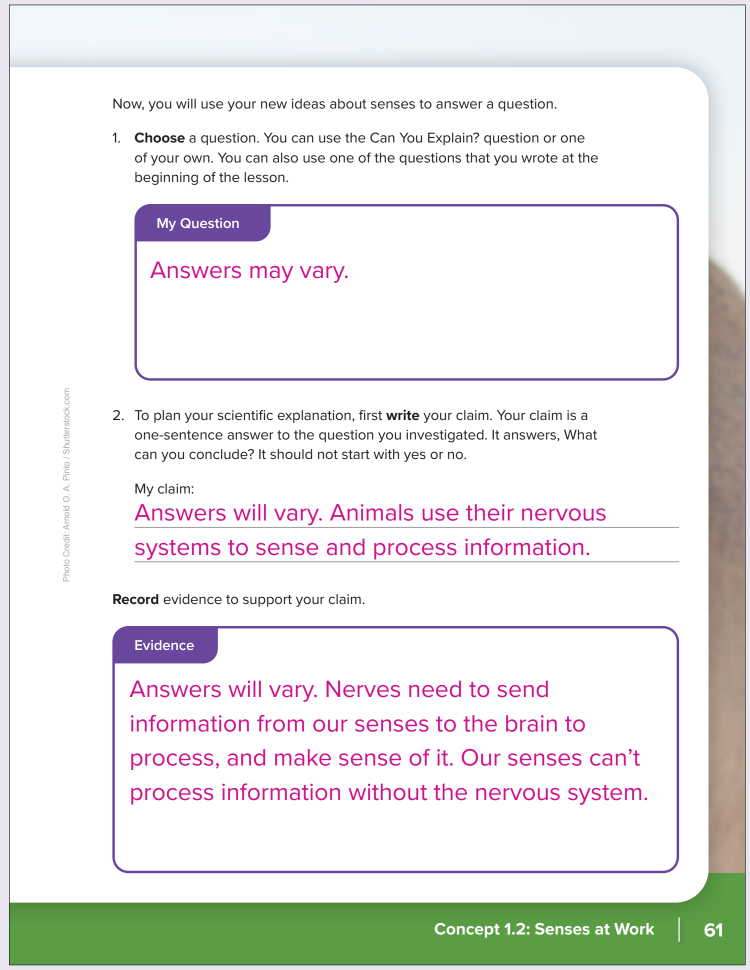

Now, you will use your new ideas about senses to answer a question.

1. **Choose** a question. You can use the Can You Explain? question or one of your own. You can also use one of the questions that you wrote at the beginning of the lesson.

My Question

Answers may vary.

2. To plan your scientific explanation, first **write** your claim. Your claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with yes or no.

My claim:
Answers will vary. Animals use their nervous systems to sense and process information.

Record evidence to support your claim.

Evidence

Answers will vary. Nerves need to send information from our senses to the brain to process, and make sense of it. Our senses can't process information without the nervous system.

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1.2 | **Share** How do animals sense and process information?

Now, **write** your scientific explanation.

Answers will vary. Animals receive, transmit, and process sensory information through the nervous system. All animals have sense organs. In humans, our sense organs include the eyes, nose, ears, mouth, and skin. When animals receive information from the environment, this information is transmitted to the brain through electrical impulses. When my nose smells pizza, a signal is sent to my brain, and then the brain sends signals to the rest of the body telling it how to react. The amount of time it takes to react can be different based on the sense used. I could catch a meterstick faster using sight than with just hearing. Dolphins and bats use sound echolocation to find food. The sense organs allow animals to adapt and survive in their particular environment. If they didn't have these sense organs, they would not survive.

Photo Credit: Arnold O. A. Pinto / Shutterstock.com

Optional Digital Activity 15

Analyze Like a Scientist

Careers: Become a Neuroscientist

Go online to complete this activity.

Quick Code: egs4040

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Lesson 6, *continued*

Differentiation

APPROACHING LEARNERS

Some of the vocabulary words, such as *heart, nerve,* and *sense,* may be confusing to students because they are used in other contexts. Have students make a list of any words like this that they have heard elsewhere and make sure that their definitions are correct for this context.

Because of cultural, linguistic, and economic differences, not all students may be familiar with the domain-specific words commonly used in science. As a result, some students will encounter difficulty or show a lack of confidence when reporting on their scientific explanations or engaging in scientific argument. Classroom instruction should be adapted to meet the needs of these students. Most importantly, students should be provided with a supportive learning environment that respects the discussion of their ideas.

Teacher Reflection

- How did I provide scaffolding for students to construct their scientific explanations?
- How do I know my students are ready to apply the core content knowledge to another context?

Optional Digital Activity 15

Analyze Like a Scientist

20 min

Careers: Become a Neuroscientist

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4040

Lesson 6, *continued*

Review and Assess

Activity 16
Evaluate Like a Scientist

20 min

Review: Senses at Work

Purpose

The final activity of the concept asks students to review and explain the main ideas of how organisms sense and process information.

Instructional Focus

Students first discuss and then summarize their learning in a written explanation about senses and processing information.

Life Skills **Accountability**

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas in their notes. Allow time for students to work with a partner or a small group as they discuss their learning and any additional questions they have at this point. Once discussion has ended, direct students to explain in writing how organisms sense, transmit, and react to information.

In the summative concept assessment, students will explain how animals sense, transmit, and react to information. Students will also outline the main organs of the central nervous system.

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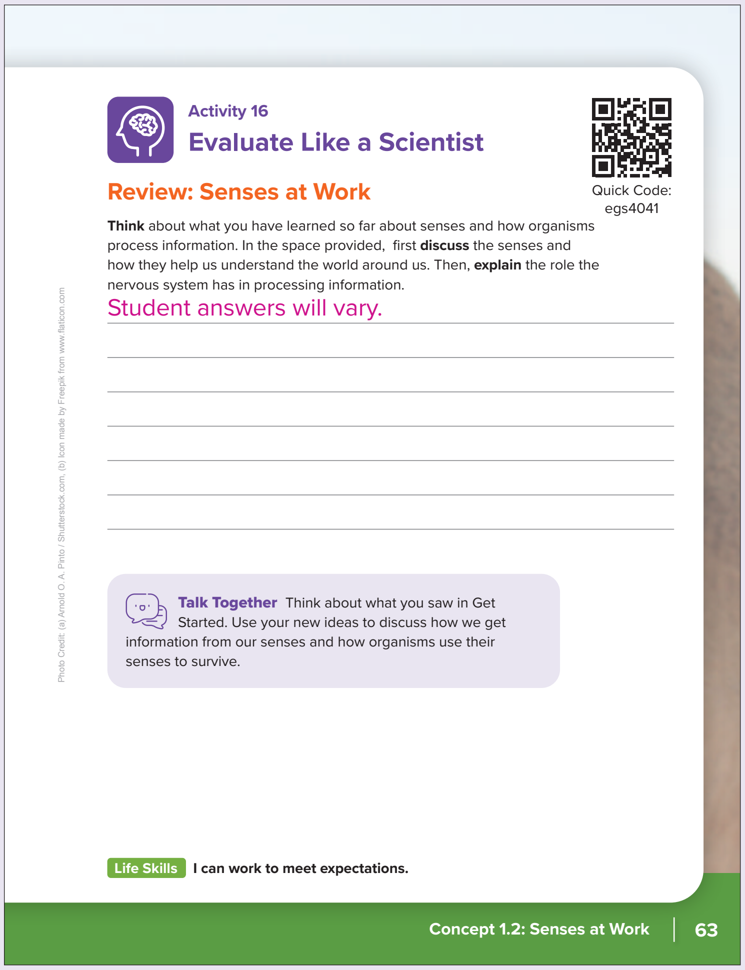

Activity 16

Evaluate Like a Scientist

Quick Code: egs4041

Review: Senses at Work

Think about what you have learned so far about senses and how organisms process information. In the space provided, first **discuss** the senses and how they help us understand the world around us. Then, **explain** the role the nervous system has in processing information.

Student answers will vary.

Talk Together Think about what you saw in Get Started. Use your new ideas to discuss how we get information from our senses and how organisms use their senses to survive.

Photo Credit: (a) Arnold O. A. Pinto / Shutterstock.com, (b) Icon made by Freepik from www.flaticon.com

Life Skills I can work to meet expectations.

Concept 1.2: Senses at Work | 63

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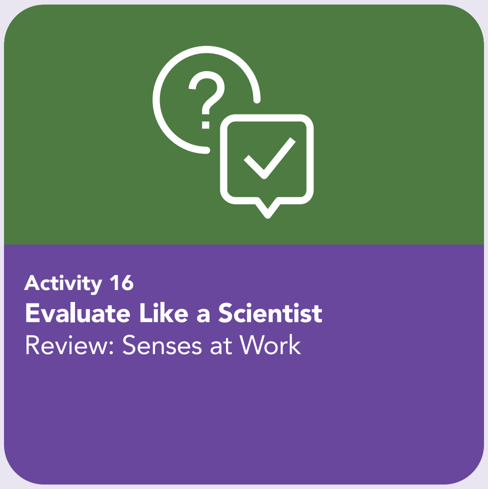

Quick Code:
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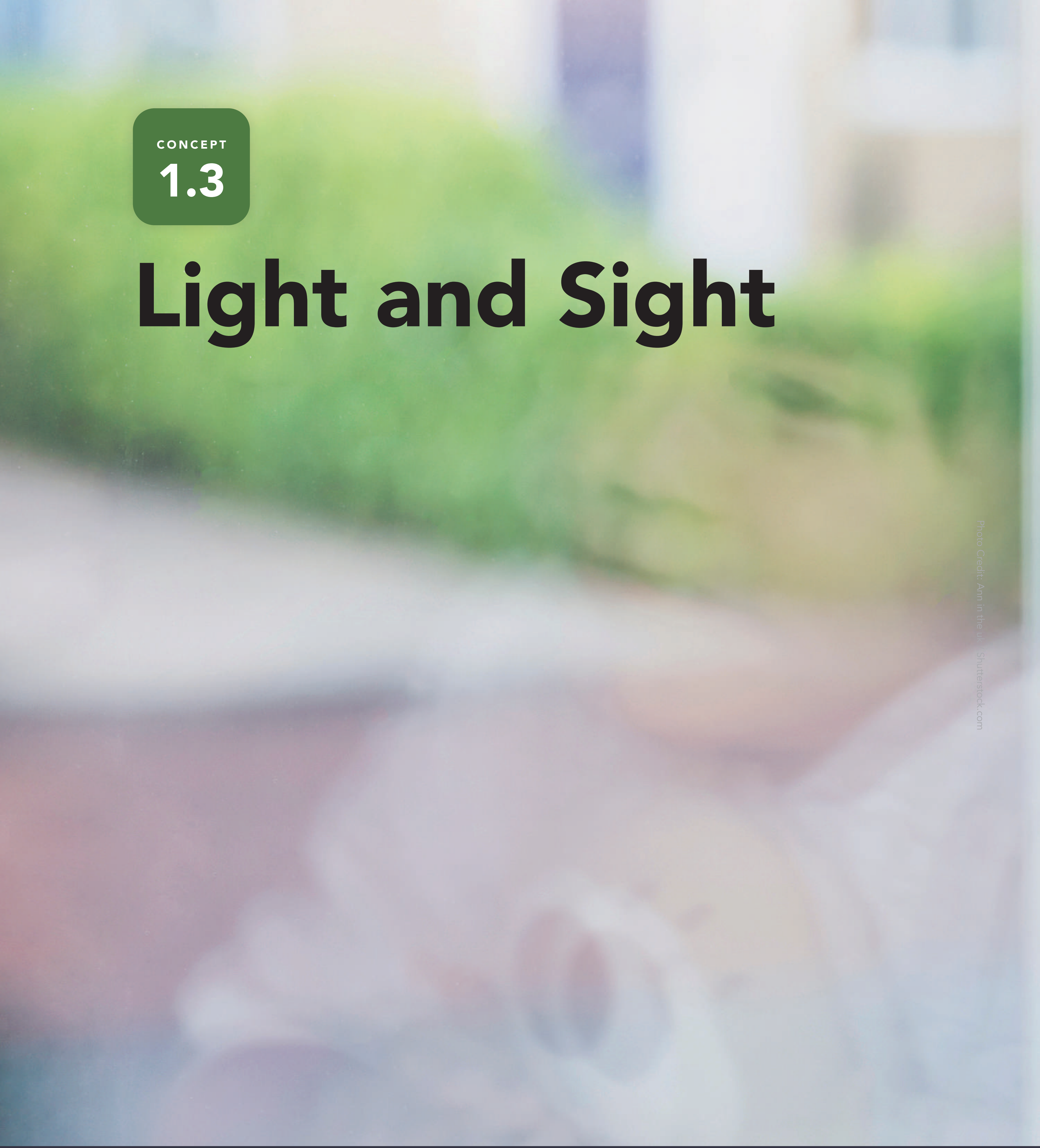
CONCEPT

1.3

Light and Sight



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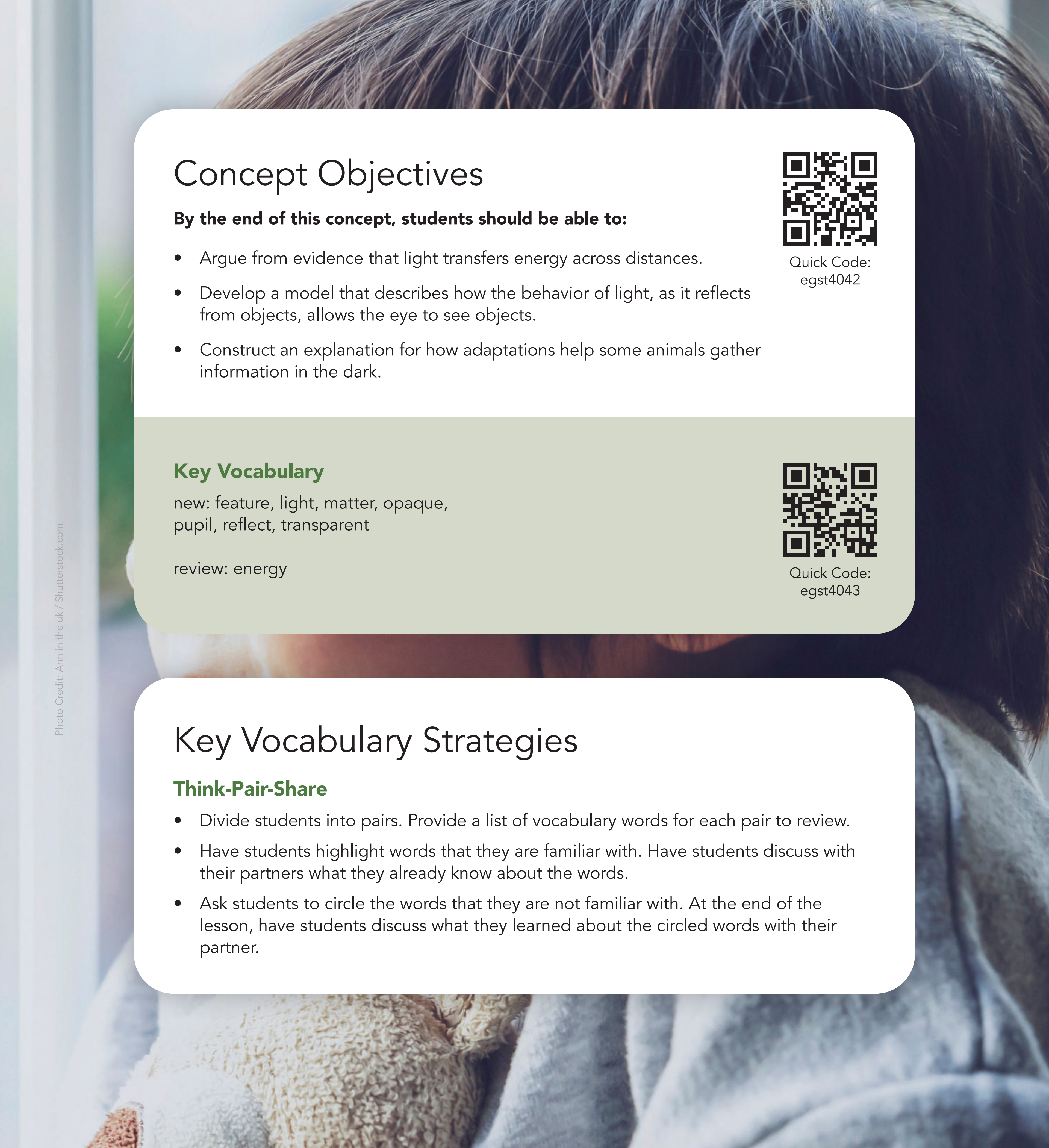

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Concept Objectives

By the end of this concept, students should be able to:

- Argue from evidence that light transfers energy across distances.
- Develop a model that describes how the behavior of light, as it reflects from objects, allows the eye to see objects.
- Construct an explanation for how adaptations help some animals gather information in the dark.

Quick Code:
egst4042

Key Vocabulary

new: feature, light, matter, opaque, pupil, reflect, transparent

review: energy

Quick Code:
egst4043

Key Vocabulary Strategies

Think-Pair-Share

- Divide students into pairs. Provide a list of vocabulary words for each pair to review.
- Have students highlight words that they are familiar with. Have students discuss with their partners what they already know about the words.
- Ask students to circle the words that they are not familiar with. At the end of the lesson, have students discuss what they learned about the circled words with their partner.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	20 min
		Activity 3	15 min
Learn	Lesson 2	Activity 4	15 min
		Activity 5	30 min
	Lesson 3	Activity 6	20 min
		Activity 7	25 min
	Lesson 4	Activity 8	30 min
		Activity 9	15 min
	Lesson 5	Activity 10	20 min
Share		Activity 11	25 min
	Lesson 6	Activity 12	20 min
		Activity 13	25 min

Content Background

What Is Light?

The term light can be used to refer to visible light—the colors that we can see—or to the entire electromagnetic spectrum. Electromagnetic radiation carries energy from place to place by way of electromagnetic waves, so light can be described as a wave. Visible light (the colors red through violet) is roughly in the middle of this spectrum. In this concept and at this age level, the term "light" refers to light we can see—visible light. However, what is visible to the human eye can be different from what other animals can see. How the eyes of various organisms process light and the ideal conditions for using the sense of sight depend on how an organism has physically adapted for survival in certain conditions.

How Have Animals Adapted to Low Light Conditions?

At this point in the unit, students have investigated the physical and behavioral adaptations of organisms in extreme climates. In very hot environments, many animals rely on a nocturnal lifestyle to survive. Feeding and hunting at night allows these animals to sleep through the hottest parts of the day, often in dark underground burrows. To support these behavioral adaptations, these animals have developed a number of structural adaptations that allow them to function in an environment that lacks an abundance of available light. Larger eyes with a wider pupil allow for the capture of any available light. Different ratios of light and color receptor cells within the eye prioritize the ability to capture light over the luxury of identifying colors for nocturnal creatures. Finally, specialized reflective structures on the back of the eyes of some nocturnal animals work like mirrors to reflect and multiply even small amounts of light. This layer of cells beneath the retina is called the *tapetum lucidum* (tapestry of light). In addition to providing nocturnal animals with the glowing quality that can be seen when light reflects off of their eyes, it allows for light to be reflected within the eye, thereby allowing the photoreceptors within the eye of the animal a second chance at processing the image.

Content Background, *continued*

How Light Travels

To understand how the eyes of nocturnal animals are adapted to process light in a way that supports survival, students must understand the phenomenon of reflection. To comprehend this process, students must understand both what light is and how it travels.

Light moves through a vacuum in straight lines and at a constant speed. It moves more slowly through matter. When light moves from one material to another, it interacts with that material. Light waves may bounce off (reflect), change speed and direction (refract), or be absorbed. When light waves hit a smooth surface, they are reflected evenly from that surface and travel away from the surface at the same angle that they hit the surface. When light waves hit a rough surface, the light waves are scattered unevenly by the different facets of the surface and travel in many directions at many angles away from the surface.

Hands-On Investigations Preparation

Learn

Location	Instructional Focus	Materials to Prepare (per group)
Activity 5: Light Observations	In this activity, students explore how light is related to sight.	• Flashlight • Small box (approximately the size of a shoebox) with two holes about 5 cm apart at one end of the box • Object that can fit inside the box
Activity 8: Reflection	In this activity, students plan and carry out an investigation about which types of objects best reflect light.	• Flashlight • Various objects made of different materials such as a plastic block, wooden block, piece of cloth, mirror, paper, piece of metal, and so on

Lesson 1

Activity 1
Can You Explain?

10 min

What needs to happen for humans and other animals to see an object in low-light areas?

Purpose

This activity draws on students' prior knowledge and personal experiences by asking them to consider what is needed to see objects in an area with low light.

Instructional Focus

In this activity, students use prior knowledge to construct an explanation of why light is needed to see in a low-light area.

Life Skills **Endurance**

Strategy

Encourage students to explain what they already know about what needs to happen to see an object in dark places. Challenge them to think about light energy and how it strikes matter.

Students may have some initial ideas about how to answer the question (see sample student response in the Student Materials page). By the end of the concept, students should be able to construct a scientific explanation that includes evidence from the concept activities.

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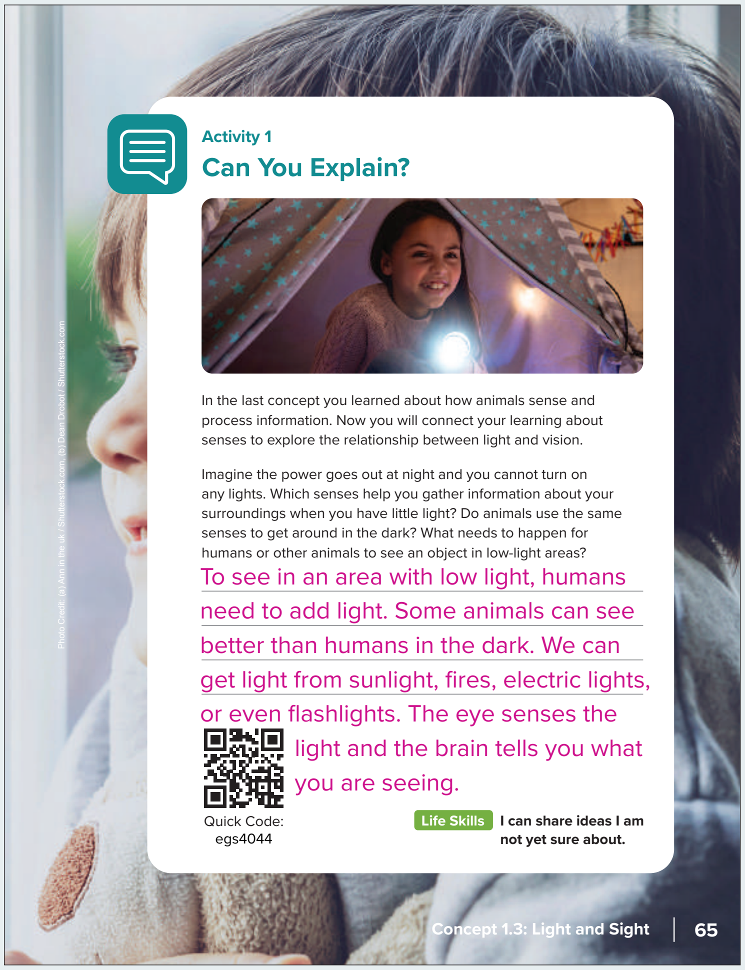

Activity 1

Can You Explain?

In the last concept you learned about how animals sense and process information. Now you will connect your learning about senses to explore the relationship between light and vision.

Imagine the power goes out at night and you cannot turn on any lights. Which senses help you gather information about your surroundings when you have little light? Do animals use the same senses to get around in the dark? What needs to happen for humans or other animals to see an object in low-light areas?

To see in an area with low light, humans need to add light. Some animals can see better than humans in the dark. We can get light from sunlight, fires, electric lights, or even flashlights. The eye senses the light and the brain tells you what you are seeing.

Quick Code: egs4044

Life Skills I can share ideas I am not yet sure about.

Concept 1.3: Light and Sight | 65

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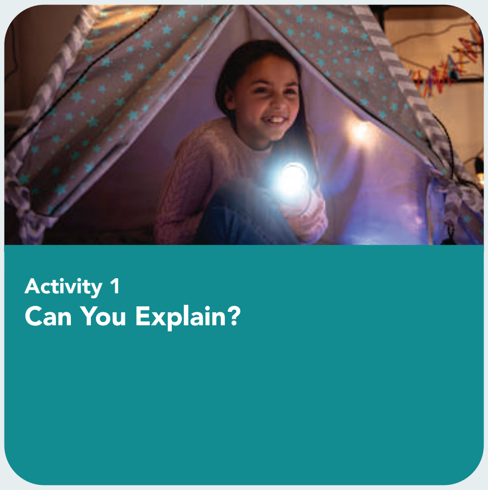

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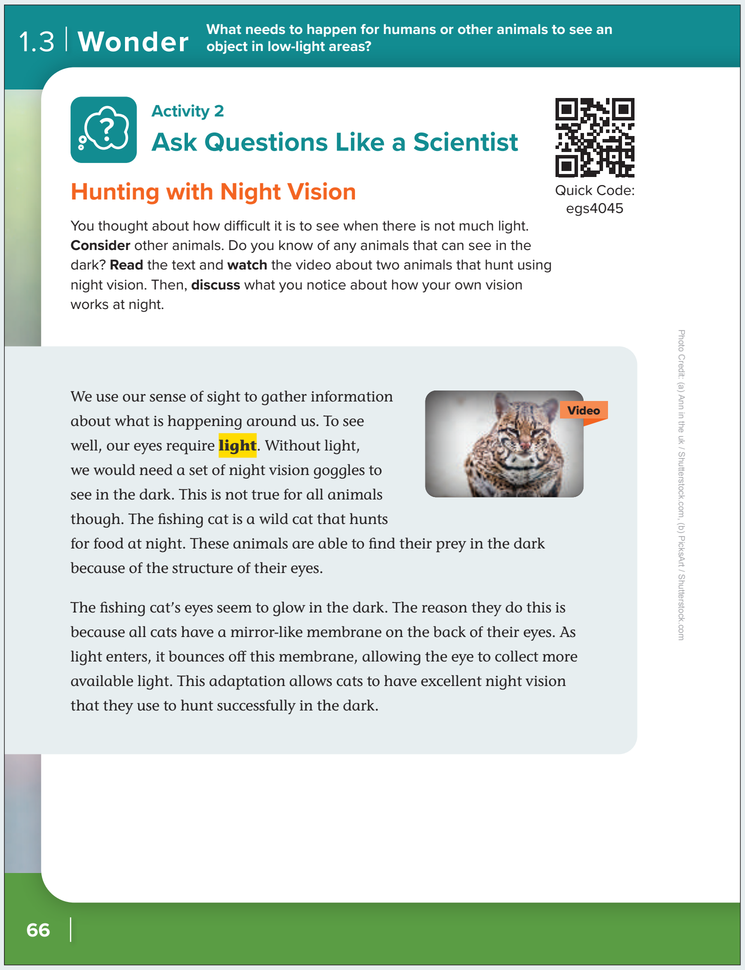

1.3 | Wonder What needs to happen for humans or other animals to see an object in low-light areas?

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4045

Hunting with Night Vision

You thought about how difficult it is to see when there is not much light. **Consider** other animals. Do you know of any animals that can see in the dark? **Read** the text and **watch** the video about two animals that hunt using night vision. Then, **discuss** what you notice about how your own vision works at night.

We use our sense of sight to gather information about what is happening around us. To see well, our eyes require **light**. Without light, we would need a set of night vision goggles to see in the dark. This is not true for all animals though. The fishing cat is a wild cat that hunts for food at night. These animals are able to find their prey in the dark because of the structure of their eyes.

Video

The fishing cat's eyes seem to glow in the dark. The reason they do this is because all cats have a mirror-like membrane on the back of their eyes. As light enters, it bounces off this membrane, allowing the eye to collect more available light. This adaptation allows cats to have excellent night vision that they use to hunt successfully in the dark.

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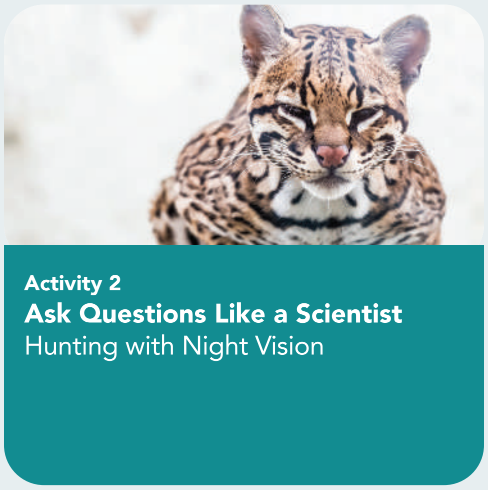

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Investigative Phenomenon

Activity 2

Ask Questions Like a Scientist

20 min

Hunting with Night Vision

Purpose

The Investigative Phenomenon sparks curiosity in students as they begin to consider how the sense of vision works. This activity asks students to share questions about the relationship between light and vision.

Instructional Focus

In this activity, students ask questions about the relationship between light and vision and use these questions as a basis for defining problems and possible solutions.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Students have investigated some aspects of how senses work. Use this activity to encourage students to think in more detail about how the sense of vision works. What questions do students have? Make a class list of questions to revisit throughout the concept. Invite students to continue adding to the questions throughout the lessons and finding answers through their work.

Lesson 1, *continued*

- Ask students if they know of any animals that can see in the dark. Then, show students the video *Let's Investigate Hunting with Night Vision* and ask them to read the companion text. After watching the video and reading the text, students should discuss with a partner what they notice about how their own vision works in the day versus at night. Call on student volunteers to share something they use to help them see at night.
- Many students may have noticed that when they turn out the lights at night, their eyes slowly adjust to the lack of light. Encourage students to reflect on why they cannot immediately see in the dark. How does the variable of light affect sight? Can people see if there is no light? Why do animals' eyes seem to get bigger in the dark?
- Gather students' ideas and use these to help them frame questions about light and vision. Encourage students to think of questions that are testable. As students reflect on their prior knowledge about sight, encourage them to begin thinking about possible tools, objects, or processes that might be used to solve problems related to vision and frame these as questions.

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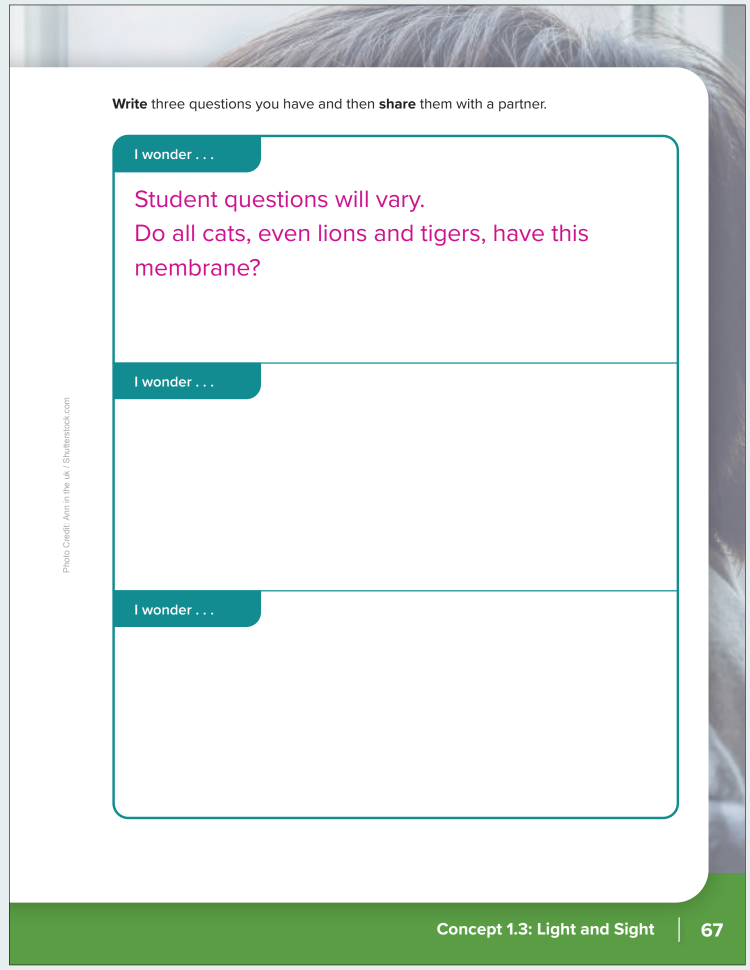

Write three questions you have and then **share** them with a partner.

I wonder . . .

Student questions will vary.
Do all cats, even lions and tigers, have this membrane?

I wonder . . .

I wonder . . .

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Concept 1.3: Light and Sight | 67

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1.3 | **Wonder** What needs to happen for humans or other animals to see an object in low-light areas?

Activity 3

Evaluate Like a Scientist

What Do You Already Know About Light and Sight?

Quick Code: egs4047

Sources of Light

A source of light is something that gives off its own light. There are objects that **reflect** light. These objects are not considered a source of light. **Look** at the pictures. **Circle** the pictures that show sources of light.

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Activity 3

Evaluate Like a Scientist

What Do You Already Know About Light and Sight?

Quick Code: egst4047

Lesson 1, *continued*

Activity 3

Evaluate Like a Scientist

15 min

What Do You Already Know About Light and Sight?

Purpose

In this formative assessment, students share their current understanding about sources of light. Students make an inference about the relationship between a source of light and how we can see an object that does not produce its own light. This understanding sets the stage for further learning about how vision works.

Instructional Focus

In this activity, students communicate current understandings of how light sources play a role in vision.

Strategy

Students should complete the formative assessment items to provide evidence of prior knowledge related to light and sight.

The items Sources of Light and How We See provide a formative assessment of students' existing knowledge of sources of light and the process of vision.

Be alert for misconceptions conflating sources of light with the reflection of light. For now, help students understand that a light source is an object that produces its own light, such as the sun or a light bulb.

Sources of Light

Strategy

The assessment item Sources of Light provides a formative assessment of students' existing knowledge about sources of light.

Lesson 1, *continued*

After the assessment, ask students to identify all the sources of light in the classroom. If all students do not agree on specific sources, record these sources for discussion after students have completed further activities.

How We See

Strategy

The item How We See provides a formative assessment of what students know about the causal relationships involved in sight.

To extend this activity, provide students with an opportunity to test these relationships directly. For example, provide a red ball and turn off the lights. Are students able to see the red ball? To illustrate for students that our eyes do not produce the light that enables us to see, you could either show the anatomy of the eye or note that light has a definite speed and discuss how that implies that it is light traveling and not our "eye beams" traveling. Unfortunately, roughly 50 percent of adults believe in some version of "eye beams," and the evidence against it is not especially simple.

Teacher Reflection

Based on my data:

- What content do my students already know?
- What misconceptions do my students have at this point in the course?
- Are any of my students ready for extension at this point in the lesson?

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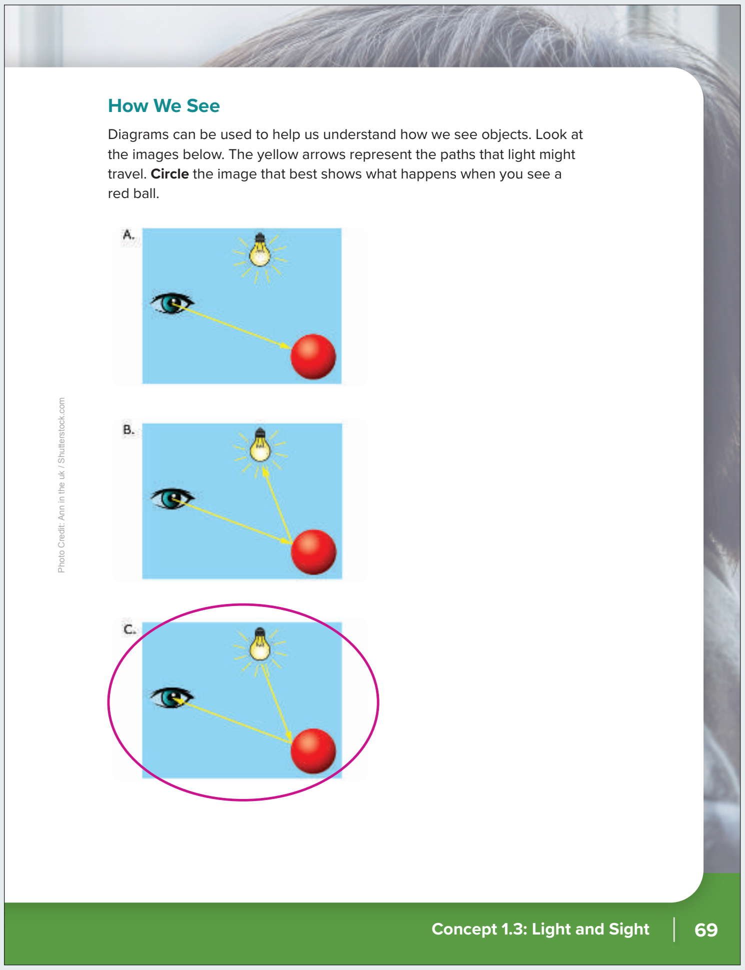

How We See

Diagrams can be used to help us understand how we see objects. Look at the images below. The yellow arrows represent the paths that light might travel. **Circle** the image that best shows what happens when you see a red ball.

A.

B.

C.

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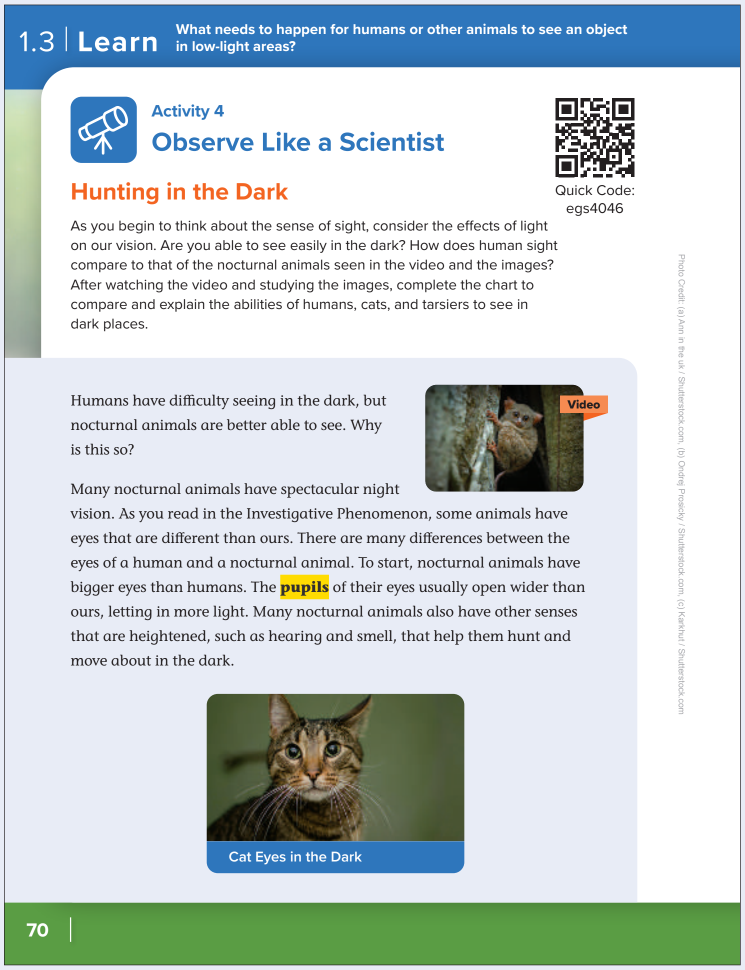

1.3 | Learn What needs to happen for humans or other animals to see an object in low-light areas?

Activity 4

Observe Like a Scientist

Hunting in the Dark

Quick Code: egs4046

As you begin to think about the sense of sight, consider the effects of light on our vision. Are you able to see easily in the dark? How does human sight compare to that of the nocturnal animals seen in the video and the images? After watching the video and studying the images, complete the chart to compare and explain the abilities of humans, cats, and tarsiers to see in dark places.

Humans have difficulty seeing in the dark, but nocturnal animals are better able to see. Why is this so?

Video

Many nocturnal animals have spectacular night vision. As you read in the Investigative Phenomenon, some animals have eyes that are different than ours. There are many differences between the eyes of a human and a nocturnal animal. To start, nocturnal animals have bigger eyes than humans. The **pupils** of their eyes usually open wider than ours, letting in more light. Many nocturnal animals also have other senses that are heightened, such as hearing and smell, that help them hunt and move about in the dark.

Cat Eyes in the Dark

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Activity 4
Observe Like a Scientist
Hunting in the Dark

Quick Code:
egst4046

Lesson 2

Activity 4
Observe Like a Scientist

15 min

Hunting in the Dark

Purpose

Students begin their investigation into sight by considering the differences between the eyes of animals and humans. This activity sets the stage for future investigations into the importance of light for sight and the structure of the eye that enables us to see.

Instructional Focus

In this activity, students watch a video to observe the abilities of tarsiers to see at night. Students also read a text and view images to begin to explain the abilities of humans, cats, and tarsiers to see in dark places.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning. Direct students to watch the video *Tarsiers Hunt at Night* and read the companion text. After reading the text and watching the video, encourage students to discuss what surprised them and what new information was learned.

Next, ask students to view the images Cavers and Cat Eyes in the Dark. Guide discussion using the following questions:

ASK

- *After learning about the tarsier, what do you notice about the images?*
  Possible answers may include: The cat's eyes are big. They can see in the dark better than us. The cavers need light to be able to see in the dark.

Lesson 2, *continued*

ASK

- *Why are some animals adapted to see at night?*
  They may hunt for prey at night, or they may need to avoid predators.
- *How are their eyes different from and similar to ours?*
  Their eyes are larger to gather more light, and their eyes are more sensitive to light.
- *Can any of them see in complete darkness?*
  Animals can detect very faint light levels, but in complete darkness, they rely on other senses, such as hearing, smell, and touch.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- How will I organize this differently next year?
- Were students able to think about how we see in low light levels?

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Let's look at the tarsier as an example. It is a tiny primate from Southeast Asia, about 10 centimeters long, not including its tail. These tiny mammals must search for insects, small lizards, or birds to eat, even though there is little light available. Like owls, tarsiers' huge eyes gather and reflect any light available to give them a picture of their surroundings. Also like owls, tarsiers' eyes are so big that they cannot move in their sockets. Instead the tarsier can turn its head 180 degrees.

After reading and observing, **complete** the chart to **explain** the abilities of humans, cats, and tarsiers to see in dark places.

Photo Credit: Ann in the uk / Shutterstock.com

Adapting to the Dark		
Humans	Cats	Tarsiers
Humans need outside light sources to help us see in the dark. Our eyes do not let in as much light as cats or tarsiers.	Cat eyes are much more sensitive and let in more light than humans. This lets them have good night vision.	Tarsiers have huge eyes that can see almost everything in the dark. They can turn their head like an owl to help them focus in the dark on objects near or far away.

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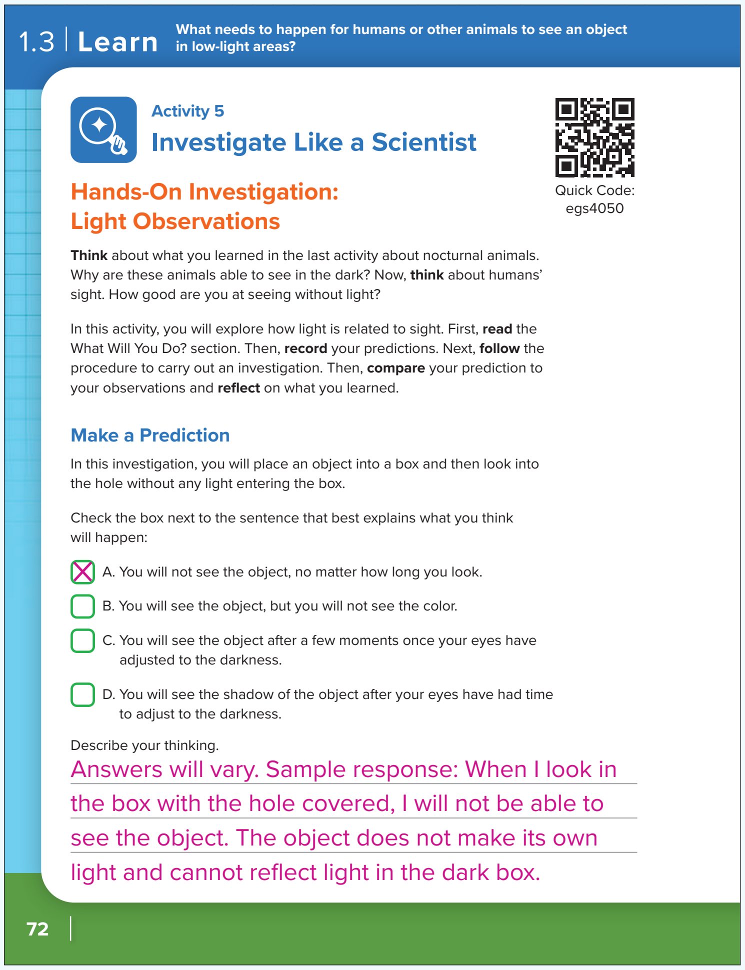

1.3 | Learn What needs to happen for humans or other animals to see an object in low-light areas?

Activity 5

Investigate Like a Scientist

Quick Code: egs4050

Hands-On Investigation: Light Observations

Think about what you learned in the last activity about nocturnal animals. Why are these animals able to see in the dark? Now, **think** about humans' sight. How good are you at seeing without light?

In this activity, you will explore how light is related to sight. First, **read** the What Will You Do? section. Then, **record** your predictions. Next, **follow** the procedure to carry out an investigation. Then, **compare** your prediction to your observations and **reflect** on what you learned.

Make a Prediction

In this investigation, you will place an object into a box and then look into the hole without any light entering the box.

Check the box next to the sentence that best explains what you think will happen:

- [x] A. You will not see the object, no matter how long you look.
- [ ] B. You will see the object, but you will not see the color.
- [ ] C. You will see the object after a few moments once your eyes have adjusted to the darkness.
- [ ] D. You will see the shadow of the object after your eyes have had time to adjust to the darkness.

Describe your thinking.

Answers will vary. Sample response: When I look in the box with the hole covered, I will not be able to see the object. The object does not make its own light and cannot reflect light in the dark box.

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Activity 5
Investigate Like a Scientist
Hands-On Investigation: Light Observations

Quick Code:
egst4050

Lesson 2, *continued*

Activity 5
Investigate Like a Scientist

30 min

Hands-On Investigation: Light Observations

Purpose

In this activity, students investigate how light is related to sight. After having read about and observed the tarsier, students will first make a prediction about what humans need for sight. This leads to a hands-on observation in which students collect evidence and test their ideas.

Instructional Focus

In this activity, students explore how light is related to sight.

Life Skills **Collaboration**

Activity Activator: Make a Prediction

Students consider whether they can see an object in total darkness and explain their thinking in writing. To help students make a prediction, ask: *Have you ever walked into a closet and shut the door? What can you see?*

Tell students that they will complete a simple observation to collect evidence and test and clarify their previous thinking. Once the investigation is complete, students discuss the results and reflect on what they learned. It is expected that students will be able to explain that light is needed for an eye to see an object.

Activity Procedure: What Will You Do?

1. Begin with a review of what students already know about light. Concepts may include what light is, characteristics of light, and how light behaves.
2. Divide students into groups and provide them with the materials necessary to complete the investigation.

Lesson 2, *continued*

3. Instruct students to read the What Will You Do? section, and then ask students to record predictions. Encourage students to share their predictions within the group.
4. To complete the investigation, students place an object inside the box and close the lid. One student then covers one of the holes with their hand and looks through the other hole. Next, the student removes their hand and replaces it with the flashlight, turned on. The same student looks again. All students should have a turn with the materials. Once students have completed the investigation, they record observations.
5. Discuss the results of the investigations with the class.
6. Finally, students compare their predictions to their observations and answer the question under Think About the Activity.

Analysis and Conclusions: Think About the Activity

In order to facilitate class discussion on the Think About the Activity section, break up the prompt into the following two questions:

ASK

- *How do the results of your observation compare to your prediction?*
  Answers will vary. Sample response: I predicted that I would be able to see the object once my eyes adjusted to the darkness. When it was completely dark, I could not see the object at all. Some light helped me to see the object.
- *Why does light permit you to see the object in the box? Encourage students to review the diagrams in Wonder to support their answers. What happened with the light that permitted you to see the object in the box?*
  Answers will vary. Sample response: The light bounced off the object into my eyes, so I could see it.

Materials List (per group)

- Flashlight
- Small box (approximately the size of a shoebox) with lid and two small holes about 5 cm apart at one end of the box
- Object that can fit in the box

HANDS-ON INVESTIGATION

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What materials do you need? (per group)

- Flashlight
- Small box (approximately the size of a shoebox) with lid and two small holes about 5 cm apart at one end of the box
- Object that can fit in the box

HANDS-ON INVESTIGATION

What Will You Do?

1. Place the object inside the box.
2. Close the lid.
3. Cover one of the holes with your hand and look through the other hole.
4. Then, take away your hand and replace it with the flashlight, turned on.
5. Look again. What happens?
6. Using what you already know, explain your observations.

Life Skills **I can think about how my team works together.**

Concept 1.3: Light and Sight | 73

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1.3 | **Learn** **What needs to happen for humans or other animals to see an object in low-light areas?**

Observations

Record what you saw in the box.

When I looked through the hole without any light,

Answers will vary. Sample response: I was not able to see the object.

When I looked through the hole with the flashlight shining,

Answers will vary. Sample response: I could see the object clearly when the light from the flashlight was shining into the box.

How could you improve this investigation to better understand how light is needed for sight?

Answers will vary. Sample response: I would allow different amounts of light to enter the box to see how much light is needed for sight.

Think About the Activity

Reread your prediction. **Think** about your investigation and your class discussion. What do you know now? Think about what you learned and **write** about any experiences that changed your thinking.

Answers will vary. Sample response: I predicted that I would be able to see the object once my eyes adjusted to the darkness. When it was completely dark, I couldn't see the object at all. Some light is necessary to see the object because the light reflects off the object into my eye.

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Lesson 3

What Is Light?

Activity 6
Analyze Like a Scientist

20 min

Light Is Energy

Purpose

In this activity, students begin to build evidence to support their findings in the previous hands-on investigation. By reading the text Light Is Energy, students discover how light transfers energy from one place to another.

Instructional Focus

In this activity, students gather evidence for how vision works in low light and how light transfers energy from one place to another.

Life Skills **Creativity**

Strategy

Students will begin building evidence for how we see in the dark by reading the text Light Is Energy.

- Ask students to read the text straight through one time.
- Then, have students identify the main ideas of the text. Ask how they can illustrate these ideas. Have them discuss what they would choose as an illustration for each paragraph. Students should then share their thoughts with a partner. Do they agree? Can they come to consensus?
- Finally, have students complete a sketch of the illustrations they choose for each paragraph.

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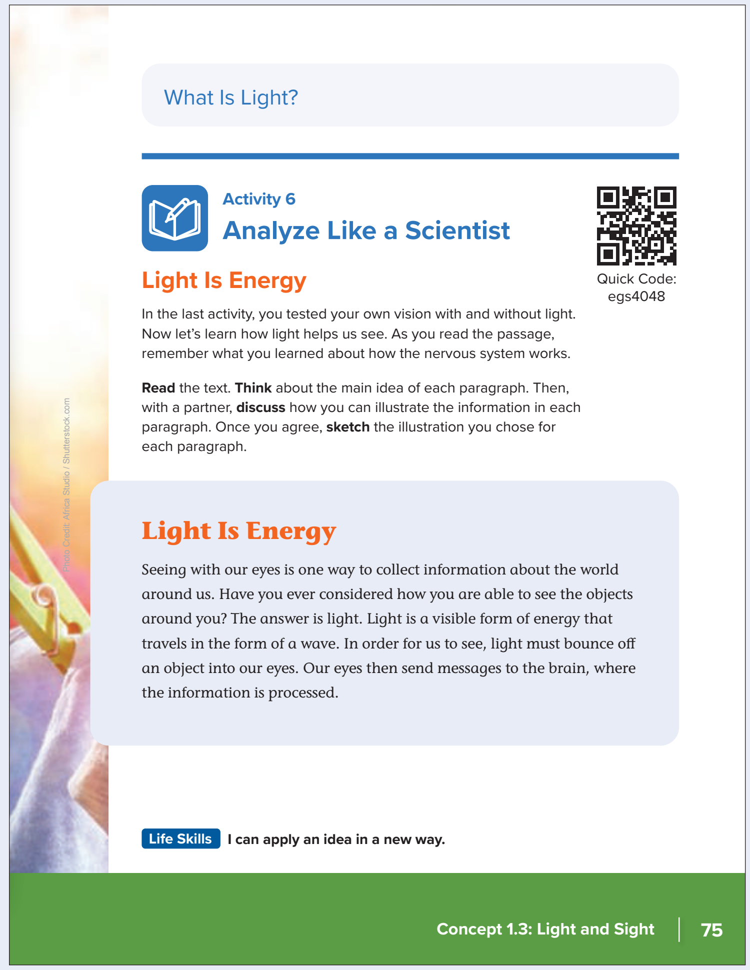

What Is Light?

Activity 6

Analyze Like a Scientist

Quick Code: egs4048

Light Is Energy

In the last activity, you tested your own vision with and without light. Now let's learn how light helps us see. As you read the passage, remember what you learned about how the nervous system works.

Read the text. **Think** about the main idea of each paragraph. Then, with a partner, **discuss** how you can illustrate the information in each paragraph. Once you agree, **sketch** the illustration you chose for each paragraph.

Light Is Energy

Seeing with our eyes is one way to collect information about the world around us. Have you ever considered how you are able to see the objects around you? The answer is light. Light is a visible form of energy that travels in the form of a wave. In order for us to see, light must bounce off an object into our eyes. Our eyes then send messages to the brain, where the information is processed.

Life Skills I can apply an idea in a new way.

Concept 1.3: Light and Sight | 75

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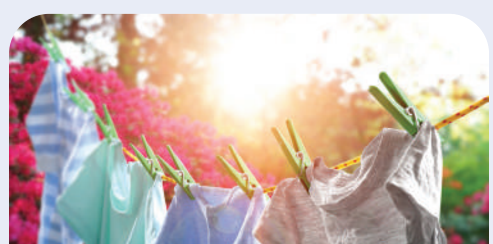

Activity 6
Analyze Like a Scientist
Light Is Energy

Quick Code:
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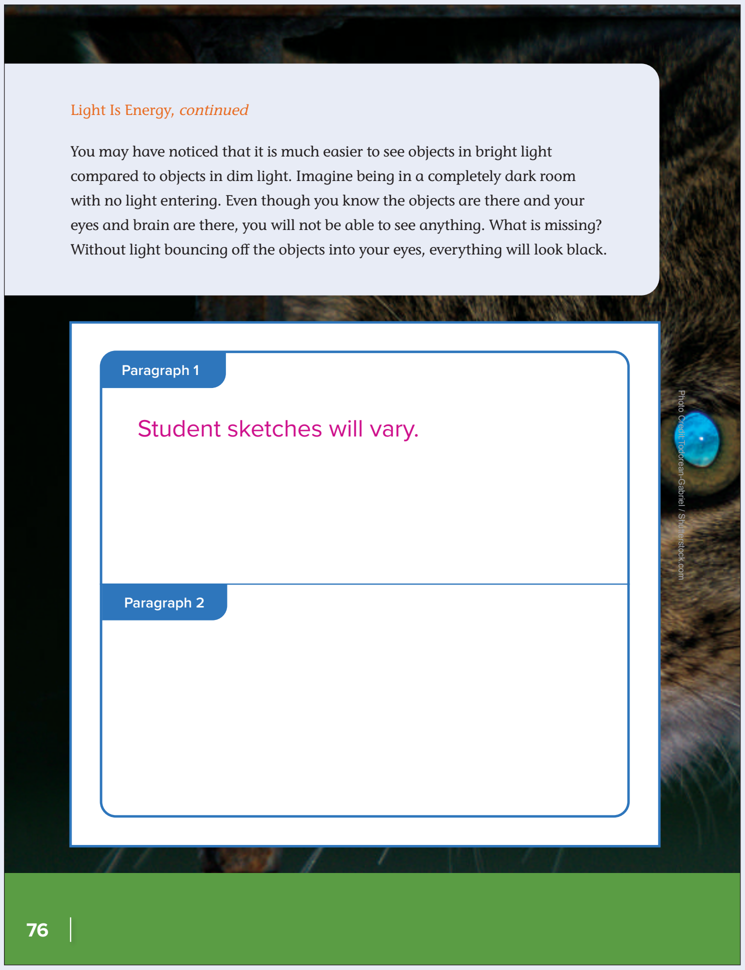

Light Is Energy, *continued*

You may have noticed that it is much easier to see objects in bright light compared to objects in dim light. Imagine being in a completely dark room with no light entering. Even though you know the objects are there and your eyes and brain are there, you will not be able to see anything. What is missing? Without light bouncing off the objects into your eyes, everything will look black.

Paragraph 1
Student sketches will vary.

Paragraph 2

76

Lesson 3, *continued*

After they complete their sketches, have students review the models with a partner, discussing the following guiding questions:

- What is the purpose of this model?
- How do the sketches show the flow of energy?
- Do the sketches show any cause-and-effect relationships?

Lesson 3, *continued*

Activity 7
Analyze Like a Scientist

25 min

Special Eye Structures

Purpose

In their explorations of light, students have tested the limitations of their own sense of sight in low light conditions. Students have begun to think about how light moves in a straight line. In this activity, students will learn about a structural feature in the eye of some animals that allows them use very small amounts of light in a highly effective way. Becoming familiar with this phenomenon will allow students to have a real-world example to draw upon as they investigate reflection in the next activity.

Instructional Focus

In this activity, students will look for evidence to explain how some animals' eyes are structured to use light reflection in order to function exceptionally well in low light conditions.

Strategy

Prior to reading the text, ask students if they have ever seen a cat outside at night, especially near a road. Ask them to consider if they noticed anything remarkable about the way the cat's eyes appeared in the darkness.

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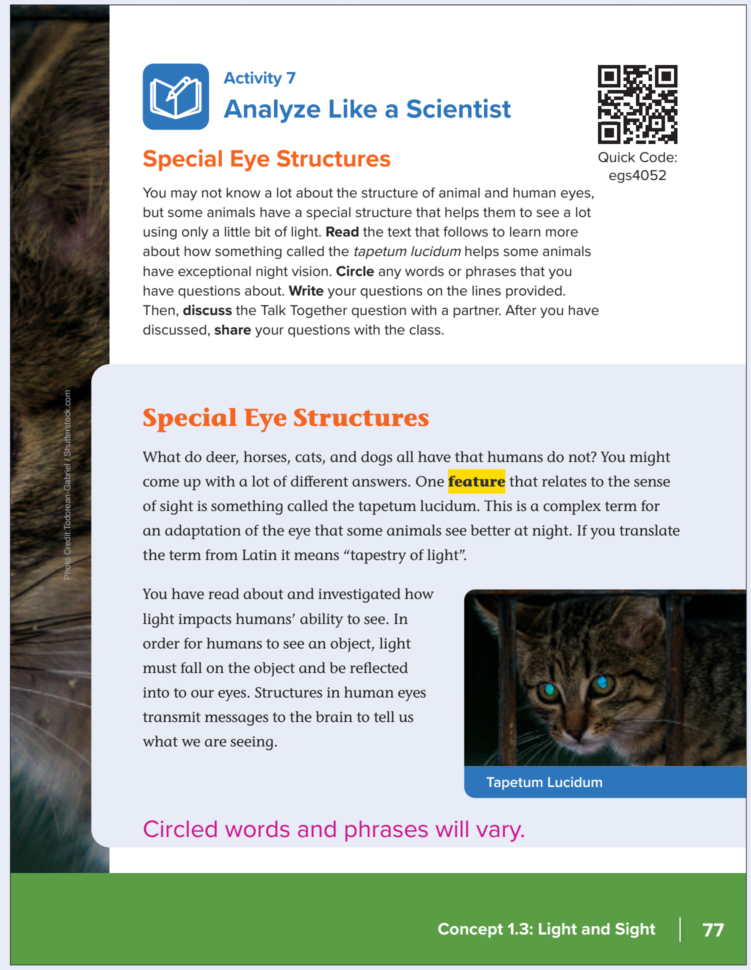

Activity 7

Analyze Like a Scientist

Special Eye Structures

Quick Code: egs4052

You may not know a lot about the structure of animal and human eyes, but some animals have a special structure that helps them to see a lot using only a little bit of light. **Read** the text that follows to learn more about how something called the *tapetum lucidum* helps some animals have exceptional night vision. **Circle** any words or phrases that you have questions about. **Write** your questions on the lines provided. Then, **discuss** the Talk Together question with a partner. After you have discussed, **share** your questions with the class.

Special Eye Structures

What do deer, horses, cats, and dogs all have that humans do not? You might come up with a lot of different answers. One **feature** that relates to the sense of sight is something called the tapetum lucidum. This is a complex term for an adaptation of the eye that some animals see better at night. If you translate the term from Latin it means "tapestry of light".

You have read about and investigated how light impacts humans' ability to see. In order for humans to see an object, light must fall on the object and be reflected into to our eyes. Structures in human eyes transmit messages to the brain to tell us what we are seeing.

Tapetum Lucidum

Circled words and phrases will vary.

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Concept 1.3: Light and Sight | 77

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Quick Code:
egst4052

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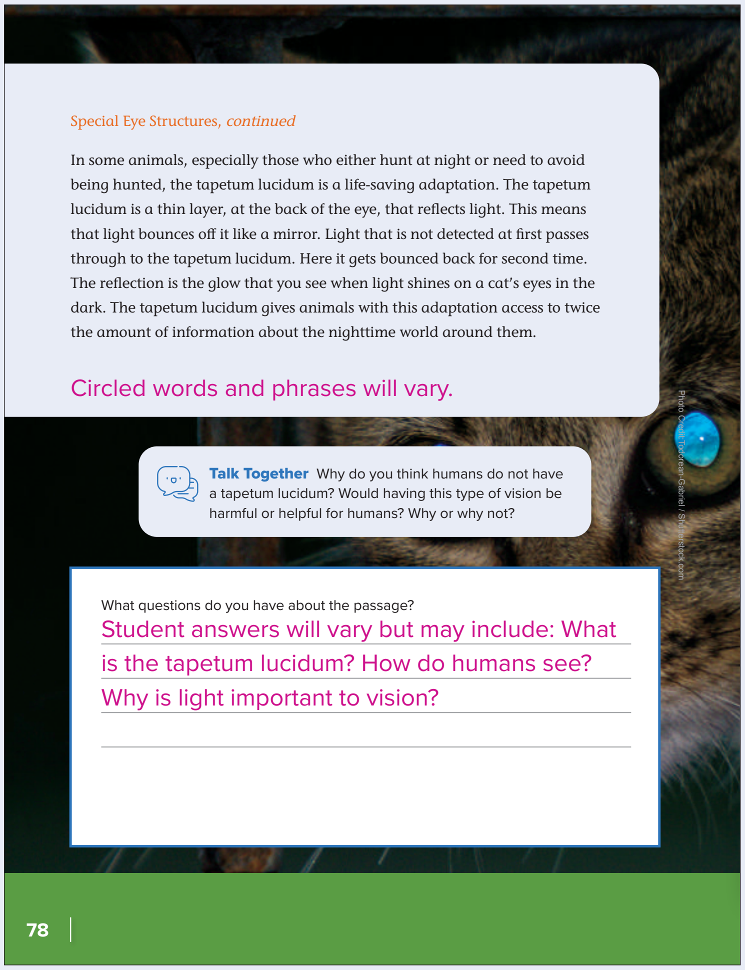

Special Eye Structures, *continued*

In some animals, especially those who either hunt at night or need to avoid being hunted, the tapetum lucidum is a life-saving adaptation. The tapetum lucidum is a thin layer, at the back of the eye, that reflects light. This means that light bounces off it like a mirror. Light that is not detected at first passes through to the tapetum lucidum. Here it gets bounced back for second time. The reflection is the glow that you see when light shines on a cat's eyes in the dark. The tapetum lucidum gives animals with this adaptation access to twice the amount of information about the nighttime world around them.

Circled words and phrases will vary.

Talk Together Why do you think humans do not have a tapetum lucidum? Would having this type of vision be harmful or helpful for humans? Why or why not?

What questions do you have about the passage?

Student answers will vary but may include: What is the tapetum lucidum? How do humans see? Why is light important to vision?

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Lesson 3, *continued*

ASK

- *What did you notice about the eyes of the cat, especially if headlights of a car were shining on the animal?*
  Student answers will vary but they may recall a time that they have seen an animal in the dark with eyes that appeared to glow.
- *Why do you think the eyes of a cat appear to glow?*
  Student answers will vary but students may understand that this glow is part of an adaptation that helps nocturnal animals to see well at night.
- *Why would a cat's eyes need any type of adaptation to see well at night?*
  Cats are nocturnal animals. Wild cats hunt for prey at night.

Next, pair students with a partner and ask them to read the text Special Eye Structures, circling any words or phrases they have questions about. Once they have finished reading, allow time for students to first discuss their questions with a partner (or small group), and then encourage a class discussion to elicit all student questions. It is not important for all of the questions to be answered at this time, but it is important for students to engage with the text and think about how structural adaptations (such as the special eye structure) can help animals survive.

Lesson 4

What Happens When Light Strikes Matter?

Activity 8
Investigate Like a Scientist

30 min

Hands-On Investigation: Reflection

Purpose

To fully understand how sight adaptations support the survival of animals in low light conditions, students must have a basic understanding of how light behaves. In the last activity, students learned about a reflective layer of cells within some animals' eyes, the tapetum lucidum. To further explore how light is processed within the eye, this activity invites students to explore the phenomenon of reflection using a variety of materials.

Instructional Focus

In this activity, students plan and carry out an investigation about which types of objects best reflect light.

Life Skills **Decision-Making**

Materials List (per group)

- Flashlight
- Various objects made of different materials (such as a plastic block, wooden block, piece of cloth, mirror, paper, piece of metal, window, and so on)

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Use the flashlight only as needed for your investigation. Do not shine the flashlight at other students.
- Do not eat or drink anything in the lab.

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What Happens When Light Strikes Matter?

Activity 8

Investigate Like a Scientist

Quick Code: egs4053

Hands-On Investigation: Reflection

During the last activity, you learned about a special feature in some animals' eyes that reflects light and improves night vision. In this activity, you will investigate how light interacts with different types of materials. **Use** your flashlight to **investigate** which objects are reflective and which are not. **Identify** qualities that are common in the reflective materials.

Make a Prediction

Which objects do you think will reflect light best? **Write** and **explain** your prediction.

Predictions will vary. Students should provide a prediction based on the objects provided and give a valid explanation to support their prediction.

What Will You Do?

1. Choose four objects of different materials to investigate.
2. Shine your flashlight on each object.
3. Observe how the light interacts with the material.
4. Record how well the material reflects the light.
5. Fill in the chart with your results.

Life Skills I can analyze a situation.

Concept 1.3: Light and Sight | 79

DIGITAL

Quick Code:
egst4053

Lesson 4, *continued*

Activity Activator: Make a Prediction

In this activity, students will demonstrate that light can be reflected, and they will compare how well different materials reflect light. Display the various objects available for students to test. Ask students to select three objects and predict which of the objects will reflect light best.

Activity Procedure: What Will You Do?

To introduce the activity, review qualitative observation techniques. Students will not be able to take quantitative measurements in this case, so they will have to describe their experimental results fully.

1. Divide the class into groups of three to five students.
2. Allow each group to select four of the objects that you had previously prepared.
3. Instruct each group to make a prediction about which of the objects will reflect light best.
4. Students shine the flashlight on each object and thoroughly describe their results.

Lesson 4, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *Review your prediction. Did the results of the investigation provide evidence that supported your prediction? Or did they provide evidence against your prediction? Describe how you know.*
  Student answers will vary but should note whether the evidence supported their prediction and why. For example: Our prediction that the small mirror would reflect the most light was supported by our investigation because we saw a larger glare (or reflection) on the mirror than on the cloth.
- *Based on your results, which types of materials reflect light the best? Which reflect light poorly? Explain your answer.*
  Student answers will vary. For example, the shiny objects tended to reflect light the best, whereas the rougher objects tended to reflect light the worst.

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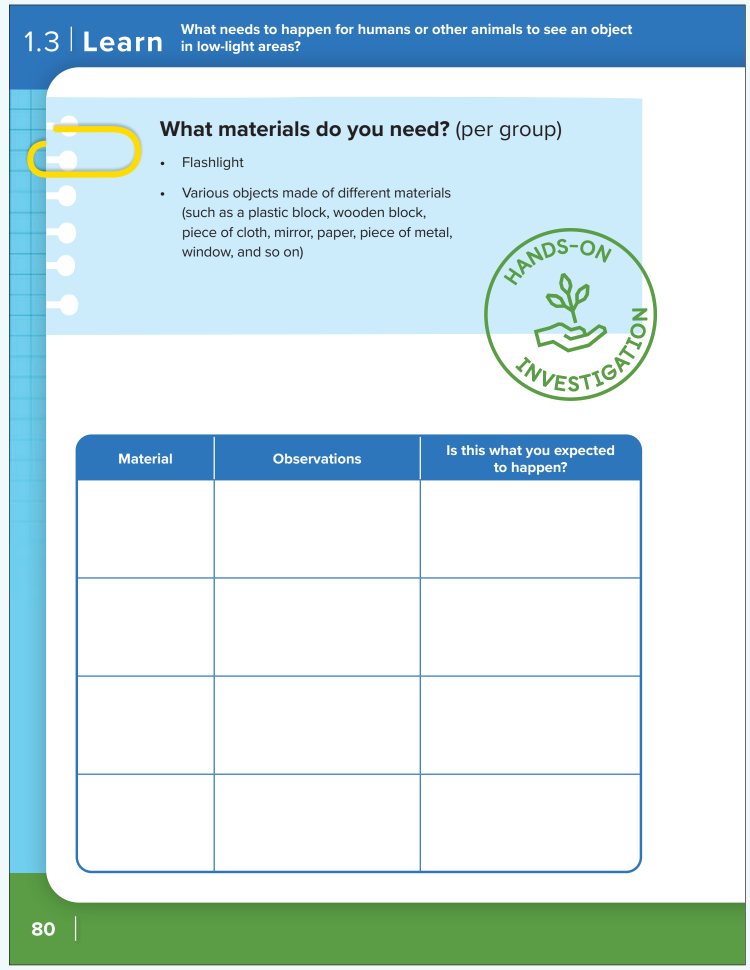
1.3 | Learn What needs to happen for humans or other animals to see an object in low-light areas?

What materials do you need? (per group)

- Flashlight
- Various objects made of different materials (such as a plastic block, wooden block, piece of cloth, mirror, paper, piece of metal, window, and so on)

Material	Observations	Is this what you expected to happen?

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Think About the Activity

Review your prediction. Did the results of the investigation provide evidence that supported your prediction? Or did they provide evidence against your prediction? **Describe** how you know.

Student answers will vary but should note whether the evidence supported their prediction and why. For example: Our prediction that the small mirror would reflect the most light was supported by our investigation because we saw a larger glare (or reflection) on the mirror than on the cloth.

Based on your results, which types of materials reflect light the best? Which reflect light poorly? **Explain** your answer.

Student answers will vary. For example: shiny objects tended to reflect light better than rough objects.

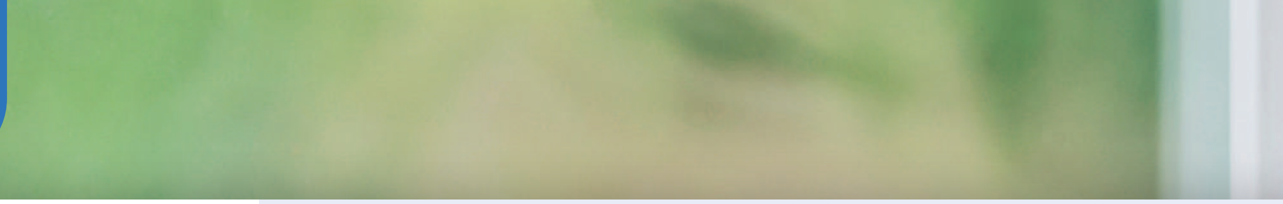
Draw a picture of your results showing the paths of the reflecting light rays.

Student drawings will vary but should include rays emanating from a light source and reflecting at the same angle at which they struck the object originally.

Lesson 4, *continued*

ASK

- *Draw a picture of your results showing the paths of the reflecting light rays.*
  Student drawings will vary, but they should include rays emanating from a light source and reflecting at the same angle at which they struck the object originally.
- *If you were going to build a model to represent the tapetum lucidum, what would you use? Which qualities would make this a good choice?*
  Student answers will vary but students should suggest materials that possess qualities that are reflective, with qualities such as smooth and shiny.



Activity 9
Analyze Like a Scientist

15 min

Light Strikes Matter

Purpose

Many sensory adaptations in animals are designed to help them survive in situations where they have limited access to light. To further understand the structure of some animals' eyes, students investigated how light reflects off of various materials. In this activity, students build upon this understanding as they further explore the nature of light as it relates to sight.

Instructional Focus

In this activity, students look for evidence to explain how light behaves when it interacts with different types of matter.

Strategy

Some knowledge of how light interacts with matter is needed for students to understand how animals, including humans, can observe objects. Have students imagine they are standing outside on a sunny day.

ASK

- *Why do you see your shadow?*
  Shadows happen because all the light that hits your body either bounces off or is absorbed. None of the light passes through you.
- *What is happening to the light when a shadow is made?*
  Some of the light is absorbed, and the rest of the light is reflected.
- *Can you think of any situations where knowing how light interacts with different materials could be useful?*
  Student answers will vary. Students may consider examples such as building houses or designing coverings for windows.

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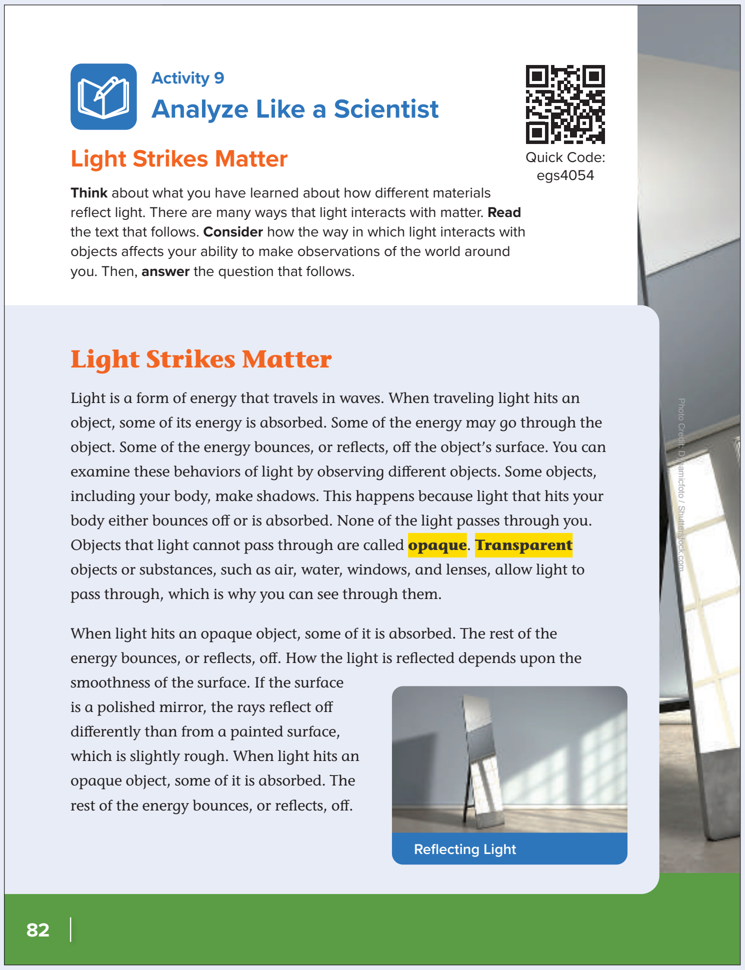

Activity 9

Analyze Like a Scientist

Light Strikes Matter

Quick Code: egs4054

Think about what you have learned about how different materials reflect light. There are many ways that light interacts with matter. **Read** the text that follows. **Consider** how the way in which light interacts with objects affects your ability to make observations of the world around you. Then, **answer** the question that follows.

Light Strikes Matter

Light is a form of energy that travels in waves. When traveling light hits an object, some of its energy is absorbed. Some of the energy may go through the object. Some of the energy bounces, or reflects, off the object's surface. You can examine these behaviors of light by observing different objects. Some objects, including your body, make shadows. This happens because light that hits your body either bounces off or is absorbed. None of the light passes through you. Objects that light cannot pass through are called **opaque**. **Transparent** objects or substances, such as air, water, windows, and lenses, allow light to pass through, which is why you can see through them.

When light hits an opaque object, some of it is absorbed. The rest of the energy bounces, or reflects, off. How the light is reflected depends upon the smoothness of the surface. If the surface is a polished mirror, the rays reflect off differently than from a painted surface, which is slightly rough. When light hits an opaque object, some of it is absorbed. The rest of the energy bounces, or reflects, off.

Reflecting Light

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Photo Credit: Dynamicfoto / Shutterstock.com

DIGITAL

Activity 9
Analyze Like a Scientist
Light Strikes Matter

Quick Code: egst4054

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How the light is reflected depends upon the smoothness of the surface. If the surface is a polished mirror, the rays reflect off differently than from a painted surface, which is slightly rougher. Rough surfaces scatter or diffuse light.

How does light striking **matter** make it possible for animals, including humans, to see? Light waves bounce off objects around us. The reflected light then travels in a straight line into our eyes. In the eyes, special nerves send messages to the brain.

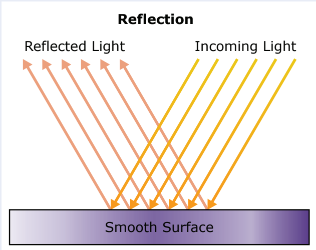

Photo Credit: Dynamicfoto / Shutterstock.com

Your older sister dropped her cell phone, and now the screen has a few cracks. How do you predict that light will reflect off the screen compared to before it was broken?

Responses will vary. Sample response: Light will not reflect the same off the broken screen. Light rays will reflect in slightly different directions from each cracked part. The light will be diffused.

Concept 1.3: Light and Sight | 83

Lesson 4, *continued*

Pair students with a partner to read the text Light Strikes Matter.

ASK *Your older sister dropped her cell phone, and now the screen has a few cracks. How do you predict that light would reflect off the screen compared to before it was broken?*

Ask students to share any prior experience that they may have with cracked screens on their devices. Students may have personally experienced a cracked cell phone screen or cracked tablet screen. What did they observe? Encourage them to share a detailed account with the class. Ask them to share any scientific principles that this phenomenon makes them wonder about.

Lesson 5

How Do We See Objects?

Activity 10
Evaluate Like a Scientist

20 min

Sight Model

Purpose

In this formative assessment, students are asked to model how the reflection of light affects the sense of sight. While students may not have a complete scientific explanation of the physics behind light, they should be able to describe the path and motion of light based on the activities completed so far.

Instructional Focus

In this activity, students use the model of a bouncing ball to study the behavior of light.

Life Skills **Creativity**

Strategy

Explain that light waves behave much like a ball when they hit a surface, so the bouncing ball is a useful model of reflection. Then, ask students how the ball model could be extended to show how we see the reflected light. Remind students what we see when reflected light enters our eyes.

If extra time is available, encourage students to attempt to build the model they describe in writing. See the Pathways to Learning table for suggestions on how to extend this activity with physical or digital models.

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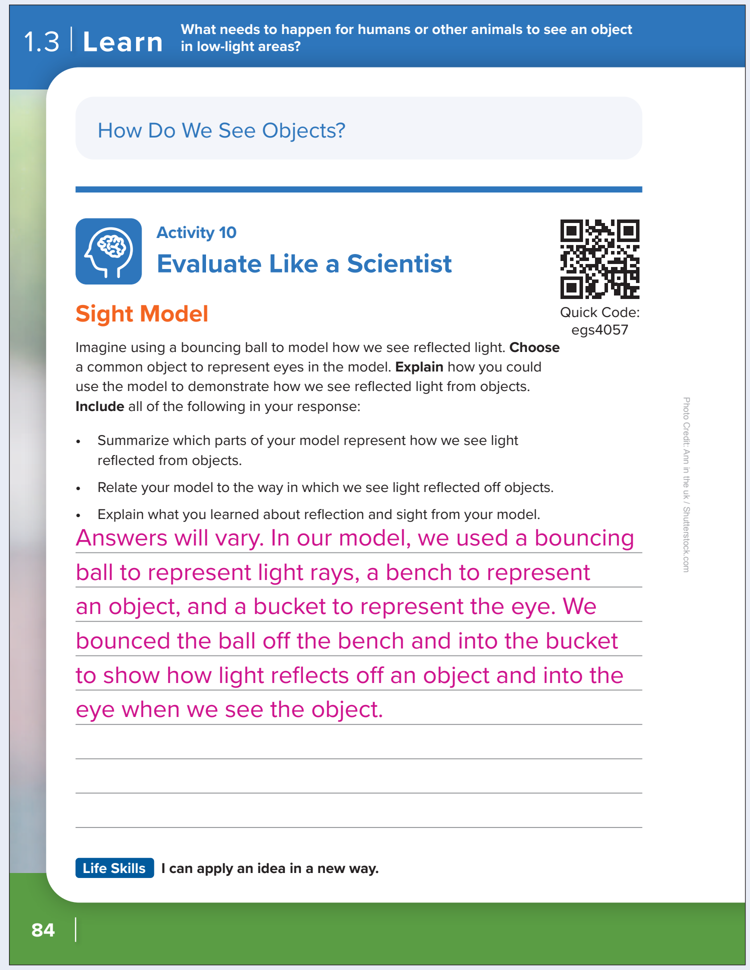
1.3 | Learn What needs to happen for humans or other animals to see an object in low-light areas?

How Do We See Objects?

Activity 10
Evaluate Like a Scientist

Quick Code: egs4057

Sight Model

Imagine using a bouncing ball to model how we see reflected light. **Choose** a common object to represent eyes in the model. **Explain** how you could use the model to demonstrate how we see reflected light from objects. **Include** all of the following in your response:

- Summarize which parts of your model represent how we see light reflected from objects.
- Relate your model to the way in which we see light reflected off objects.
- Explain what you learned about reflection and sight from your model.

Answers will vary. In our model, we used a bouncing ball to represent light rays, a bench to represent an object, and a bucket to represent the eye. We bounced the ball off the bench and into the bucket to show how light reflects off an object and into the eye when we see the object.

Life Skills I can apply an idea in a new way.

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Activity 10
Evaluate Like a Scientist
Sight Model

Quick Code:
egst4057

Pathways to Learning

Print	Discuss with the class how to create a physical model that shows how we see reflected light. As a class, brainstorm a plan for a model and develop a materials list. (You may suggest objects such as shoeboxes or baskets to represent the eye if students have suggested more expensive or unusual objects.) Next, have them explain how the model demonstrates how we see objects when light reflects from them. Have the class build one model and record their results by making a video recording.
Blended	In groups, have students complete the item Sight Model. Next, have the groups brainstorm a plan for their own model to demonstrate how we see reflected light and develop a materials list. These models can be physical or digital, using graphics to represent the planned materials. Next, have them explain how the model demonstrates how we see objects. When you are satisfied with their plans, have students collect the materials they need and demonstrate their models to the class. Have them explain how the model demonstrates how we see objects when light reflects from them.
Digital	After completing the assessment, have the class brainstorm a plan for their own digital model to demonstrate how we see reflected light and develop a materials list. Next, have students draft a digital model, using graphics to represent the planned materials. Have students explain how the model demonstrates how we see objects when light reflects from them.

MISCONCEPTION

Students often think that light travels from their eyes and illuminates an object, enabling them to see. You only see an object when light is either emitted or reflected from it. Consider having students draw a diagram to explain how they think they can see an object on your desk. Have them share their drawing and critique one another's ideas about how they see objects.

Differentiation

APPROACHING LEARNERS

Challenge students to research lighting design and think about how the eye processes different colors of light. How do theaters and museums use this type of lighting to highlight objects?

ADVANCING LEARNERS

Encourage students to complete the online STEM Project Starter Eyesight Adaptation, and then prompt them to think about how animal eyesight differs from humans'. Which adaptation would be useful for humans? Why? What could humans do with this sight adaptation?

Lesson 5, *continued*

Scientific Explanation

Activity 11
Record Evidence Like a Scientist

25 min

Hunting with Night Vision

Purpose

In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students explore the relationship between light and vision to construct explanations about how we see in the dark.

Life Skills **Self-Management**

Strategy

Guide students to review the text in the Investigative Phenomenon of Hunting with Night Vision and the Can You Explain? question. Ask students to use their experiences in Learn to consider how to explain the phenomenon. Once students have decided how best to describe the phenomenon, direct them to discuss their ideas with the class or a partner.

Once reasoning has been discussed, ask students to generate a scientific explanation to answer the Can You Explain? question. Students should write in full sentences, incorporating at least two pieces of evidence in support of their response.

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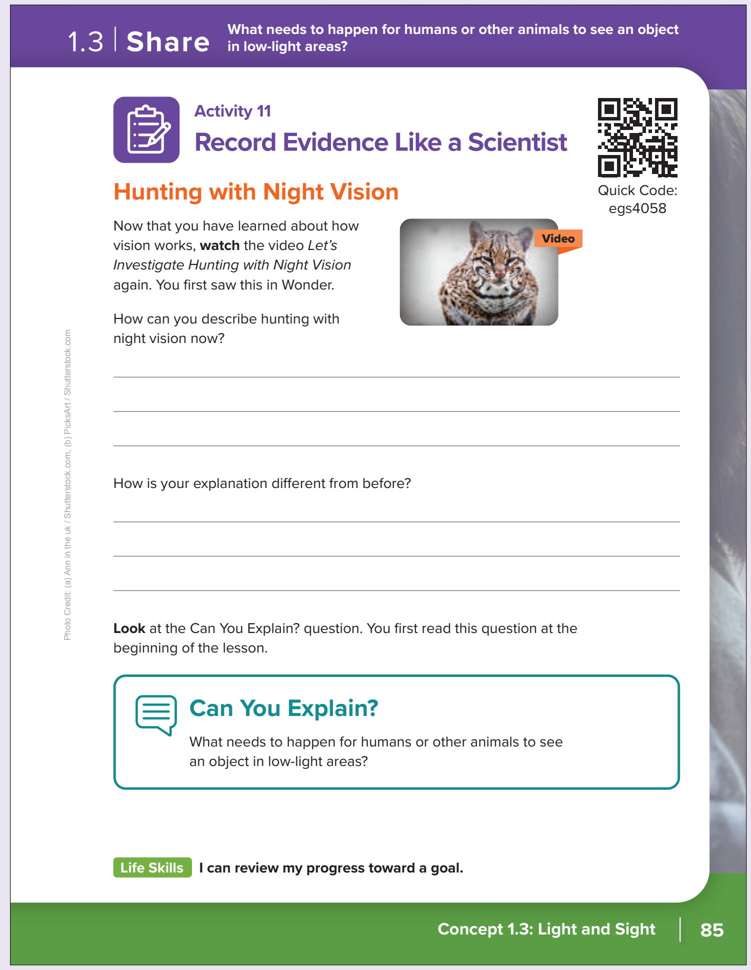
1.3 | Share What needs to happen for humans or other animals to see an object in low-light areas?

Activity 11
Record Evidence Like a Scientist

Quick Code: egs4058

Hunting with Night Vision

Now that you have learned about how vision works, **watch** the video *Let's Investigate Hunting with Night Vision* again. You first saw this in Wonder.

Video

How can you describe hunting with night vision now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?

What needs to happen for humans or other animals to see an object in low-light areas?

Life Skills **I can review my progress toward a goal.**

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Activity 11
Record Evidence Like a Scientist
Hunting with Night Vision

Quick Code:
egst4058

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1.3 | **Share** What needs to happen for humans or other animals to see an object in low-light areas?

Now, use your new ideas about how light and vision work to write a scientific explanation to answer this question. First, **write** your claim.

My claim:

Light needs to hit an object for me to see it in a low-light area.

Record evidence to support your claim.

Evidence

We wouldn't be able to see if there was no light source. There is light even in dimly lit places.

Reflection of light from objects is what lets the brain process what our eyes see.

Photo Credit: Ann in the uk / Shutterstock.com

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Lesson 5, *continued*

ASK *How can this explanation help you answer the Can You Explain? question?*

Can You Explain?

What needs to happen for humans and other animals to see an object in low-light areas?

Students have written a scientific explanation in the prior concept and should be familiar with the claim and evidence framework. In later units, students will expand scientific explanations to include a claim, evidence, and reasoning. In this activity, you may want to review the following:

A **claim** is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with yes or no.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use information from text, video, or data that supports the claim. Leave out information that doesn't support the claim.

If needed, model writing a claim and evidence framework using a student question.

Lesson 5, *continued*

Sample student response:
Animals and humans that use sight need light. When I put objects in a dark shoebox, I found that I could see the objects when there was light but could not see the objects when there was no light. We see an object when it gives off light or when light reflects off it and travels to our eyes. Some animals have an eye structure that allows them to process a lot of light. This helps them see objects others cannot in low-light areas. This adaptation gives animals who hunt or could be hunted at night an advantage in the darkness. Without a light source, humans and many animals are unable to see objects in the dark.

Differentiation

Because of cultural, linguistic, and economic differences, not all students may be familiar with the domain-specific words commonly used in science. As a result, some students will encounter difficulty or show lack of confidence when reporting on their scientific explanations or engaging in scientific argument. Classroom instruction should be adapted to meet the needs of these students. Most importantly, students should be provided with a supportive learning environment that respects the discussion of their ideas.

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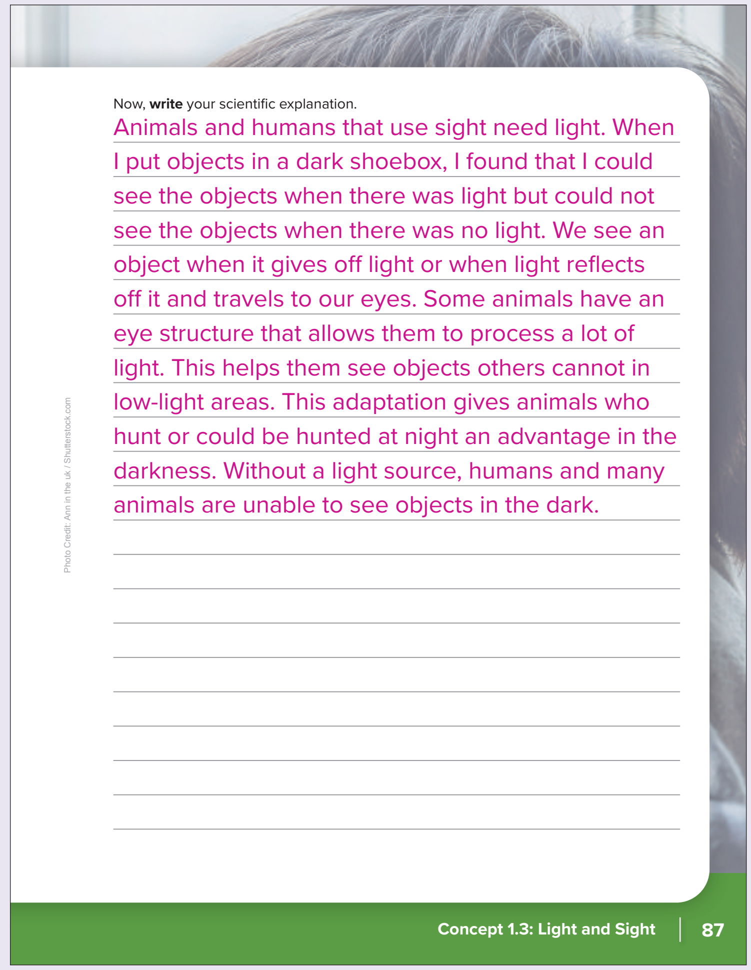
Now, **write** your scientific explanation.

Animals and humans that use sight need light. When I put objects in a dark shoebox, I found that I could see the objects when there was light but could not see the objects when there was no light. We see an object when it gives off light or when light reflects off it and travels to our eyes. Some animals have an eye structure that allows them to process a lot of light. This helps them see objects others cannot in low-light areas. This adaptation gives animals who hunt or could be hunted at night an advantage in the darkness. Without a light source, humans and many animals are unable to see objects in the dark.

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STEM in Action

Activity 12

Analyze Like a Scientist

Quick Code: egs4059

How Do Optometrists Help Us See?

Do you know anyone who wears glasses or contact lenses? Have you ever wondered how the lenses work to help humans see better? An optometrist is a health care professional who specializes in vision and eyesight.

Read the text. Then, **complete** the Eye Imperfections activity. After the activity, **discuss** your answer with your partner.

How Do Optometrists Help Us See?

When you see, what path does the light take to get to your eye? What happens when the light reaches your eye? Did you know that there is a lens just inside your eye that focuses the light onto the back of your eye?

When the lens focuses light, it redirects the light so that it all goes to a point. Think about a magnifying glass. It can take the sun's rays and concentrate them on a single point. Or it can take the light that is bouncing off something small, like an insect, and focus it on your eye.

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DIGITAL

Quick Code:
egst4059

Lesson 6

STEM in Action

Activity 12

Analyze Like a Scientist

20 min

How Do Optometrists Help Us See?

Purpose

After students have learned about the relationship between sight and light, this activity allows them to consider how optometrists can help humans see better. The passage provides background on how lenses work in the context of an important career.

Instructional Focus

In this activity, students evaluate a text to communicate information about how optometrists help people see more clearly.

Strategy

Prior to reading the text about optometrists, do a quick survey of students who wear glasses. See if any student can explain how glasses work.

ENTREPRENEURSHIP

Entrepreneurs often need to learn through experiences in addition to formal education. Optometrists use this skill when trying to apply what they learned in school to new challenges and diagnoses they encounter in real patients. Entrepreneurs look for ways to apply what they have learned from research, personal experience, and others' experiences. As students read the passage, encourage them to think of ways that an optometrist can use the entrepreneurial skill of practical application.

Lesson 6, *continued*

Eye Imperfections

Strategy

After reading the text, students should attempt the summative assessment item Eye Imperfections, in which students think like an optometrist. Students should first complete the activity individually; they may then discuss their answers in small groups or as a class. If desired, students could conduct their tests in small groups. Ideally, each group would have a student who devised a test for a different difficulty, but this is not necessary.

- As students create their eye test, remind them to think about the question they are trying to answer and the problem they are trying to solve.
- To promote student discourse, have students critique their tests by discussing the following questions: *How will the investigation you are planning answer your question about the phenomenon? What data will you be collecting? How will you collect it?*

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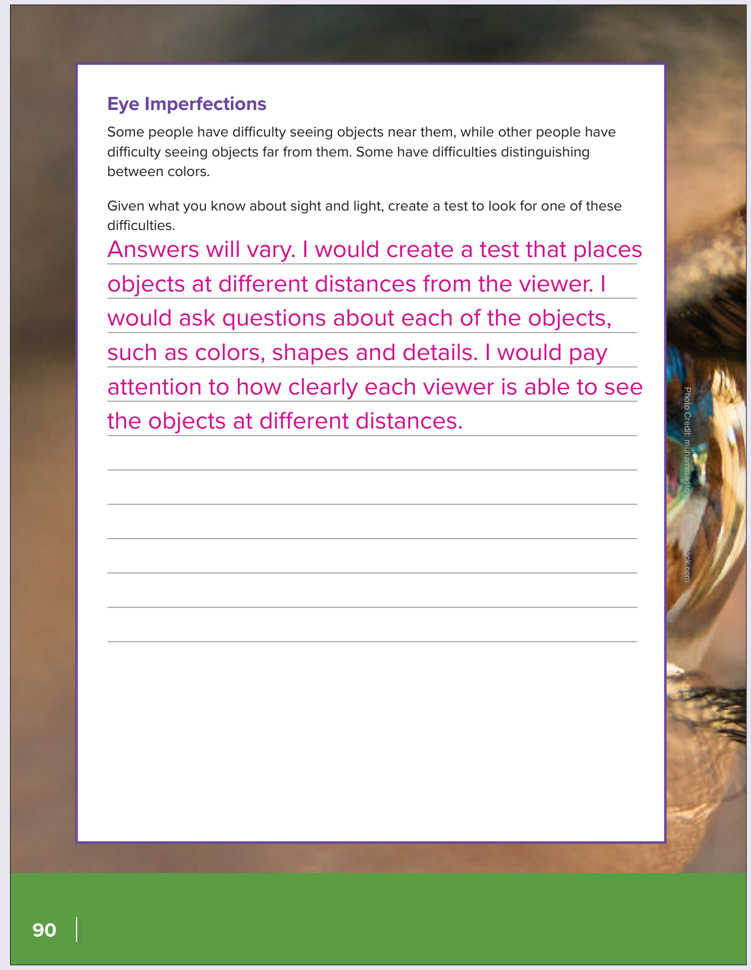

Eye Imperfections

Some people have difficulty seeing objects near them, while other people have difficulty seeing objects far from them. Some have difficulties distinguishing between colors.

Given what you know about sight and light, create a test to look for one of these difficulties.

Answers will vary. I would create a test that places objects at different distances from the viewer. I would ask questions about each of the objects, such as colors, shapes and details. I would pay attention to how clearly each viewer is able to see the objects at different distances.

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Activity 13

Evaluate Like a Scientist

Review: Light and Sight

Quick Code:
egs4060

Think about what you have learned about light and sight. Animals and humans that use sight need light to see. In the space provided, first **explain** how light travels and how it behaves when it interacts with matter. Then, explain some of the differences between how humans and some animals see.

Student responses will vary.

Talk Together Think about what you now know about light and sight. How do you think bats or other nocturnal creatures use other senses to help get around in the dark?

Concept 1.3: Light and Sight | 91

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Activity 13

Evaluate Like a Scientist

Review: Light and Sight

Quick Code:
egst4060

Review and Assess

Activity 13

Evaluate Like a Scientist

25 min

Review: Light and Sight

Purpose

The final activity of the concept asks students to review and explain the main ideas of light and sight.

Instructional Focus

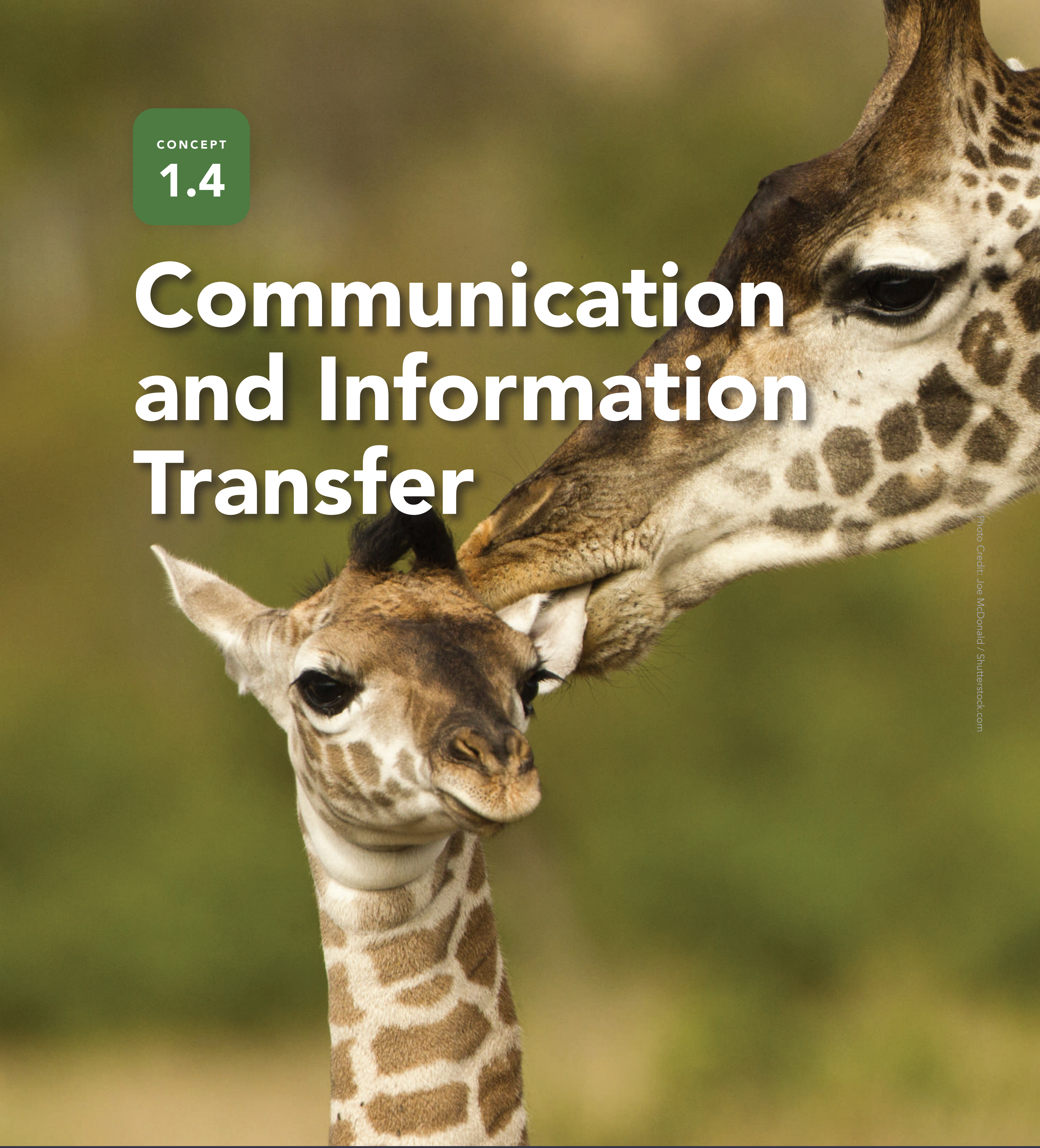
Students summarize their learning about light and sight with a written explanation and by completing a concept summative assessment.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas. You may also assign students the summative assessment for this concept.

CONCEPT 1.4

Communication and Information Transfer



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Concept Objectives

Quick Code:
egst4061

By the end of this concept, students should be able to:

- Generate and compare multiple solutions that use patterns to transfer information.
- Develop a model of a communication system that consists of many parts that work together to transfer information from one place to another.
- Argue from evidence that patterns of light and sound allow for the transfer of information through systems of communication.
- Compare systems of communication in the natural world to innovative designs and devices used in modern human societies.
- Design, test, and evaluate models of information-transfer systems that can encode, transmit, and receive information.

Key Vocabulary

Quick Code:
egst4062

new: code, echolocation, pitch satellite, system

review: adaptation

Key Vocabulary Strategies

KWL Chart

- Have students create a KWL chart, which is a three-column chart with the following heads: *What I Know, What I Would Like to Know,* and *What I Learned.*
- Have students complete the *What I Know* and *What I Would Like to Know* columns for each vocabulary word before the lesson begins. Then, have them complete the *What I Learned* column at the end of the lesson. Allow students to share their charts with the class.

Word Wizard

- Divide students into three groups. Assign a vocabulary word to each group. When a group's vocabulary word is encountered in the lesson, have them illustrate the word and write the definition. Then, have the group choose one "Word Wizard" from the group to share their definition and illustration with the class.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	15 min
		Activity 3	15 min
		Activity 4	5 min
Learn	Lesson 2	Activity 5	25 min
		Activity 6	20 min
	Lesson 3	Activity 7	45 min
	Lesson 4	Activity 8	20 min
		Activity 9	10 min
		Activity 10	15 min
Share	Lesson 5	Activity 11	25 min
		Activity 12	20 min
	Lesson 6	Activity 13	25 min
Unit Project		Begin Unit Project	20 min
	Lesson 7	Complete Unit Project	45 min

Content Background

Communication in Nature

Adaptations in the natural world are designed to help living things thrive. Throughout the first three concepts of Unit 1, students learned how behavioral and structural adaptations help animals use their senses to gather information and survive in their environments. Big ears, night vision, furry paws—all adaptations are matched with a specific survival need in a group of individual organisms. Since organisms do not live in isolation, it is also important to understand how organisms interact with each other and the natural world.

For many organisms, survival depends on effective communication during interactions with other creatures. From passing along messages regarding the availability of a food source to posturing in order to defend territory, animals rely on many systems of communication to navigate the world and convey messages to others. Various forms of communication can be employed to attract mates, show affection, defend territory, or engage in cooperative societal behavior. Signals can be auditory, visual, chemical, physical, or even electrical. At the heart of all communication in the animal kingdom is the need to send and receive messages in order to survive.

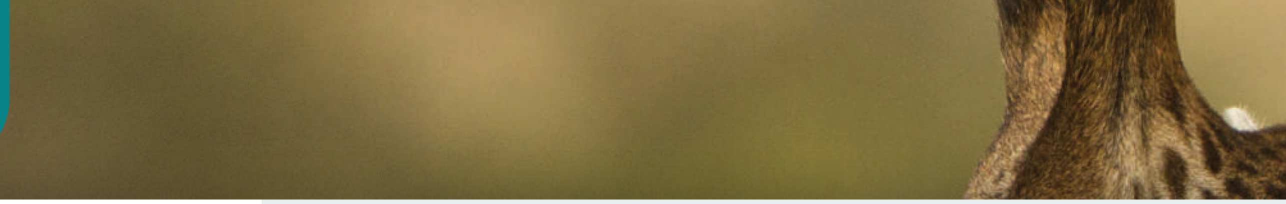
Human beings must also communicate to stay alive. Therefore, people rely on a variety of communication systems, both in the natural world and in modern society. For thousands of years, people have been improving the systems of communication utilized by other species. In the ancient world, communication was often cumbersome and difficult. Today, our world has become significantly more connected because of our increasing ability to communicate over long distances. Digital technology allows us to use complex networks to send more information over greater distances at ever-increasing speed. However complex modern systems become, the basic natural phenomena of light and sound are at the heart of how all animals, including humans, communicate.

From whale songs to the honeybee waggle dance, animals use diverse adaptations to communicate their needs. In turn, engineers have built upon nature's basic auditory and visual cues of light and sound communication to innovate modern methods of staying connected to the world around us. During this final concept, students will learn about a variety of ways that animals communicate with one another. By also gaining a basic understanding of human systems, students can appreciate the complexity of communication that exists in the natural world.

Hands-On Investigations Preparation

Learn

Location	Instructional Focus	Materials to Prepare (per group)
Activity 7: Inventing a Code	In this activity, students use patterns in light or sound to invent a unique code that they use to transfer information. Then, students identify how their code could be improved.	• Flashlight • Batteries • Notebook paper • Pencils



Lesson 1

Activity 1
Can You Explain?

10 min

How do animals, including humans, use light, sound, and other methods to send and receive information?

Purpose

In this concept, students build upon past lessons in Senses at Work to learn about communication and how information is transferred using light and sound. While learning about how technology aids in human communication, students will consider how our complex communication system has been inspired by nature.

Instructional Focus

In this activity, students think about and record what they already know about how animals, including humans, use light, sound, and other methods to communicate.

Life Skills **Endurance**

Strategy

Encourage students to explain what they already know about how animals, including humans, communicate.

Students may have some initial ideas about how to answer the question. (See sample student response in the Student Materials page.) By the end of the concept, students should be able to construct a scientific explanation that includes evidence from the concept activities.

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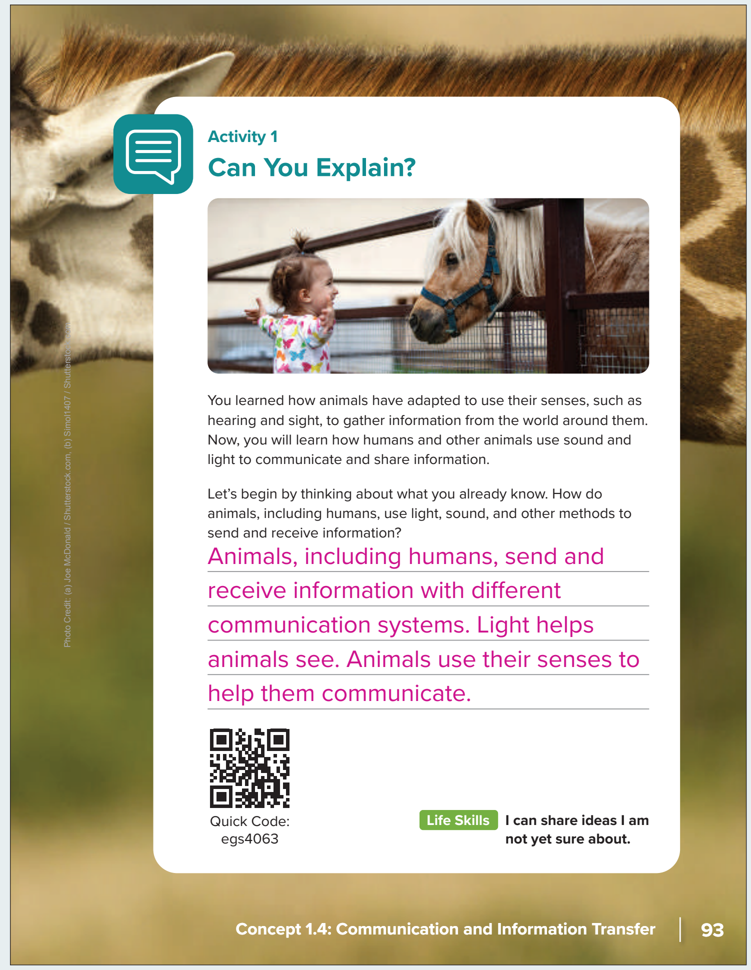
Activity 1

Can You Explain?

You learned how animals have adapted to use their senses, such as hearing and sight, to gather information from the world around them. Now, you will learn how humans and other animals use sound and light to communicate and share information.

Let's begin by thinking about what you already know. How do animals, including humans, use light, sound, and other methods to send and receive information?

Animals, including humans, send and receive information with different communication systems. Light helps animals see. Animals use their senses to help them communicate.

Quick Code: egs4063

Life Skills I can share ideas I am not yet sure about.

Concept 1.4: Communication and Information Transfer | 93

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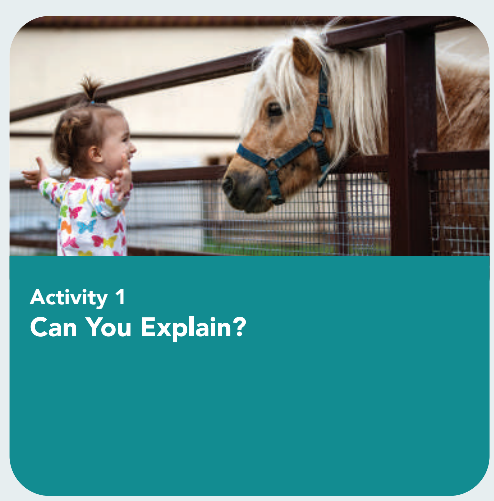

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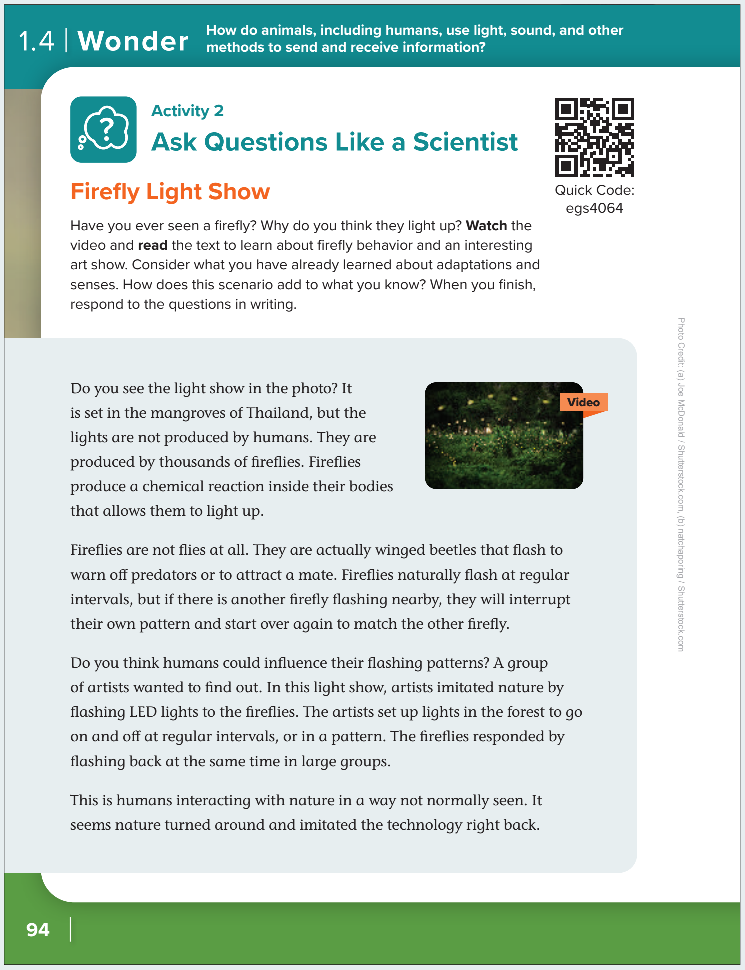

1.4 | **Wonder** **How do animals, including humans, use light, sound, and other methods to send and receive information?**

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4064

Firefly Light Show

Have you ever seen a firefly? Why do you think they light up? **Watch** the video and **read** the text to learn about firefly behavior and an interesting art show. Consider what you have already learned about adaptations and senses. How does this scenario add to what you know? When you finish, respond to the questions in writing.

Do you see the light show in the photo? It is set in the mangroves of Thailand, but the lights are not produced by humans. They are produced by thousands of fireflies. Fireflies produce a chemical reaction inside their bodies that allows them to light up.

Video

Fireflies are not flies at all. They are actually winged beetles that flash to warn off predators or to attract a mate. Fireflies naturally flash at regular intervals, but if there is another firefly flashing nearby, they will interrupt their own pattern and start over again to match the other firefly.

Do you think humans could influence their flashing patterns? A group of artists wanted to find out. In this light show, artists imitated nature by flashing LED lights to the fireflies. The artists set up lights in the forest to go on and off at regular intervals, or in a pattern. The fireflies responded by flashing back at the same time in large groups.

This is humans interacting with nature in a way not normally seen. It seems nature turned around and imitated the technology right back.

Photo Credit: (a) Joe McDonald / Shutterstock.com, (b) natchaporing / Shutterstock.com

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Photo Credit: natchaporing / Shutterstock.com

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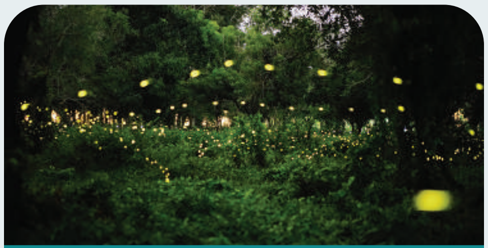


Activity 2

Ask Questions Like a Scientist

Firefly Light Show

Quick Code: egst4064

Investigative Phenomenon

Activity 2

Ask Questions Like a Scientist

15 min

Firefly Light Show

Purpose

In this Investigative Phenomenon activity, students consider the behavior of fireflies and how they use light. Students consider the role adaptation and senses play in a new scenario.

Instructional Focus

In this activity, students observe firefly behavior to analyze communication patterns. Then, students ask related questions to be investigated throughout the concept.

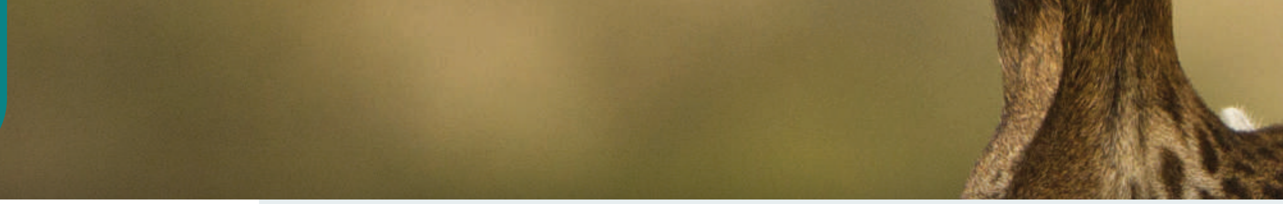
Life Skills **Negotiation**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Students have investigated how organisms adapted to their environment and the importance of sense organs in ensuring survival. They have looked in more detail at how one sense organ, the eye, is adapted to receive and, with the help of the brain, interpret information provided by light energy. In this concept, they look at the different ways that animals—including humans—use their senses to create communication systems that help them survive.

Direct students to watch the video *Firefly Light Show* and read the text to learn how fireflies communicate using light energy.



Lesson 1, *continued*

Next, create a class chart of student-generated questions related to communication and the video. Students may write their questions on sticky notes and post them, or the teacher can write the questions on chart paper during class discussion.
Sample questions might include: Is light the only way in which fireflies communicate? How do fireflies produce the light they use to communicate? Why is this communication so important to their survival? How is this similar to communication in other animals? Do humans also communicate using light? If so, how? Which methods could be used to test how other animals, such as cats and dogs, communicate?

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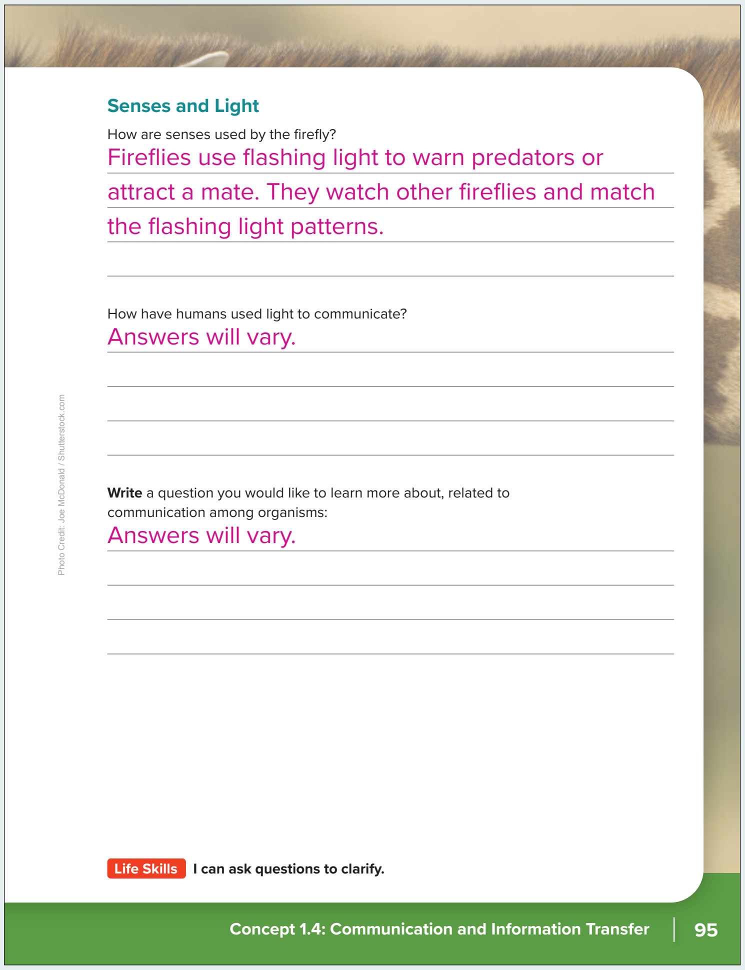

Senses and Light

How are senses used by the firefly?

Fireflies use flashing light to warn predators or attract a mate. They watch other fireflies and match the flashing light patterns.

How have humans used light to communicate?

Answers will vary.

Write a question you would like to learn more about, related to communication among organisms:

Answers will vary.

Photo Credit: Joe McDonald / Shutterstock.com

Life Skills **I can ask questions to clarify.**

Concept 1.4: Communication and Information Transfer | **95**

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1.4 | **Wonder** How do animals, including humans, use light, sound, and other methods to send and receive information?

Activity 3
Observe Like a Scientist

Quick Code: egs4065

Alphabet and Written Language

While fireflies communicate using light, people use language to communicate by reading, writing, and speaking. Can you remember when you did not know how to read or write? Why was it important for you to learn these skills? Imagine a time when written language had not yet been developed. How would humans communicate their ideas to future generations or across the country? **Watch** the video and **read** the text. **Look** for examples of how communication has changed from simple to more complex.

There are many ways to communicate and send messages. No matter how a message is sent, it must be in a language understood by the sender and the receiver. The ability to communicate through language and speech separates humans from animals.

Video

Some of the oldest writing appeared in Egypt around 3000 BCE. Ancient Egyptians created hieroglyphics, a writing system made up of about 700 symbols. The Babylonians in Mesopotamia (also around 3000 BCE) created a writing system called cuneiform drawings. In Central America, the Ancient Mayans created hieroglyphs that included almost 800 different signs.

Life Skills I can respect others' ideas.

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Photo Credit: Fedor Selivanov / Shutterstock.com

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Activity 3
Observe Like a Scientist
Alphabet and Written Language

Quick Code:
egst4065

Lesson 1, *continued*

Activate Prior Knowledge

Activity 3
Observe Like a Scientist

15 min

Alphabet and Written Language

Purpose
In this activity, students read about humans' early forms of written communication. As they read about communication in different civilizations over time, students recognize the complexity of human communication and the needs it meets.

Instructional Focus
In this activity, students obtain and evaluate information and identify patterns in early forms of communication.

Life Skills **Respect for Diversity**

Strategy
Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Students watch the video and read the text Alphabet and Written Language to discover more about early forms of communication and how these forms are applicable today. Encourage students to think about how communication has evolved from speech and gestures into complex systems that require many steps and components.

Lesson 1, *continued*

ASK *What are some similarities and differences between ancient writing systems and today's alphabet?*
Answers may vary, but students may suggest that both systems are used to record and transfer information across distance and time. Students may point out that the systems are different because we write in rows and hieroglyphics are sometimes written in columns.

Encourage student discourse by having partners share the similarities and differences they identified. Consider making a class list to compare ancient writing systems with today's alphabet.

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Letters, like those in an alphabet, were developed later. Beginning in the 15th century BCE, various cultures refined and developed a system for writing words using combinations of letters.

The Egyptians created papyrus—a kind of paper made from a reed that grows in the marshes near the Nile River. In 105 CE, the Chinese also created a form of paper using the inner bark of mulberry and bamboo fibers pounded into a pulp.

Written language allows humans to communicate with people in our present time, understand the past, and share ideas with future civilizations.

Talk Together Now, talk together about the different types of communication you saw in the video and read about in the text. What are some similarities and differences between ancient writing systems and today's alphabet?

Photo Credit: (a) Joe McDonald / Shutterstock.com, (b) Icon made by Freepik from www.flaticon.com

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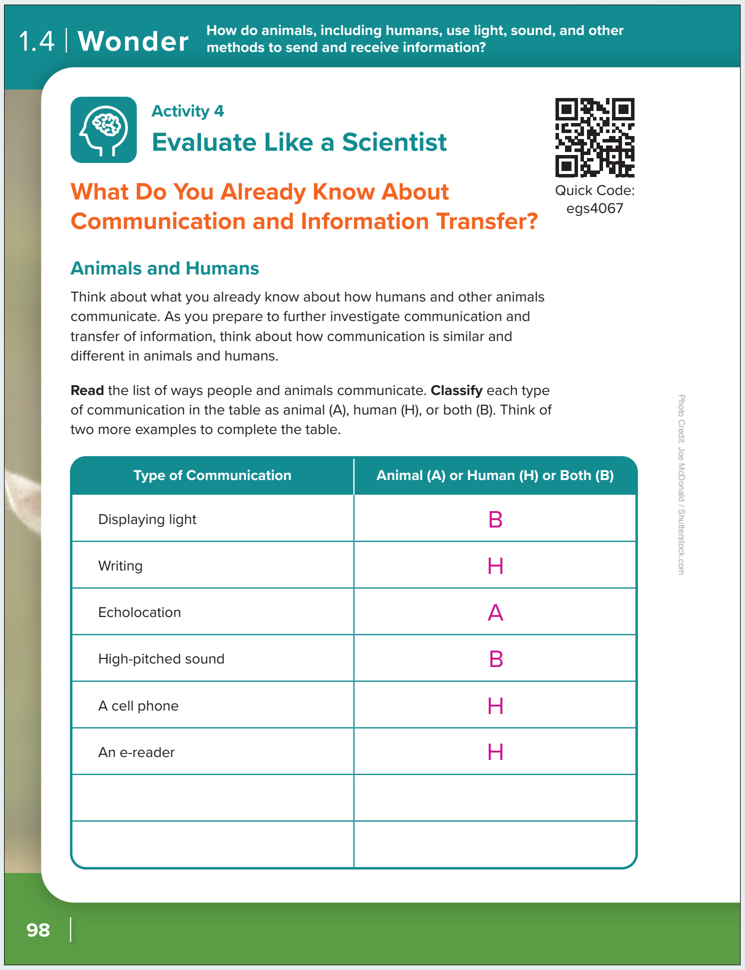

1.4 | **Wonder** How do animals, including humans, use light, sound, and other methods to send and receive information?

Activity 4

Evaluate Like a Scientist

Quick Code: egs4067

What Do You Already Know About Communication and Information Transfer?

Animals and Humans

Think about what you already know about how humans and other animals communicate. As you prepare to further investigate communication and transfer of information, think about how communication is similar and different in animals and humans.

Read the list of ways people and animals communicate. **Classify** each type of communication in the table as animal (A), human (H), or both (B). Think of two more examples to complete the table.

Type of Communication	Animal (A) or Human (H) or Both (B)
Displaying light	B
Writing	H
Echolocation	A
High-pitched sound	B
A cell phone	H
An e-reader	H

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DIGITAL

Quick Code:
egst4067

Activity 4

Evaluate Like a Scientist

5 min

What Do You Already Know About Communication and Information Transfer?

Purpose

This formative assessment captures students' existing knowledge about how animals and humans communicate. Students prepare for in-depth investigations into human and animal communication and how information is transferred.

Instructional Focus

In this activity, students reflect on what they already know about how humans and other animals communicate.

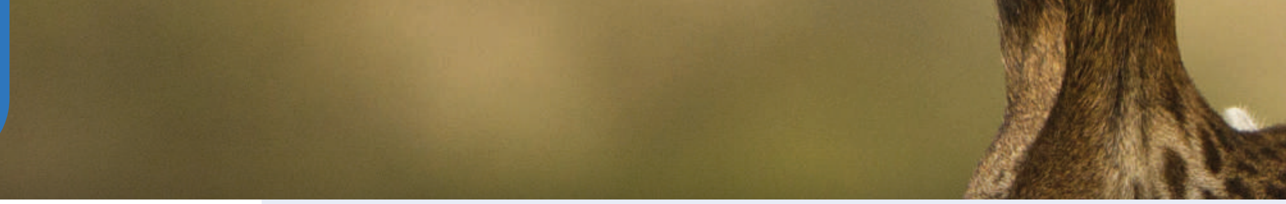
Strategy

The item Animals and Humans provides a formative assessment of students' existing knowledge of ways people communicate.

Students should complete the assessment individually. To prepare students for this assessment, consider using the SOS Stem Completion strategy by displaying images of an animal communicating, such as a tiger roaring, or a human using some sort of technology. Use examples not previously presented in the unit and have students complete sentences about them.

Stem Completion

To support students in making predictions and personal connections to the concept, use the Stem Completion strategy.



Lesson 2

Activity 5
Observe Like a Scientist

25 min

Song of Whales

Purpose
Throughout the first three concepts, students learned about how the senses can be used to receive information about the world. In this activity, students expand on this understanding by exploring how senses can also be used to transfer information, or communicate.

Instructional Focus
In this activity, students explore patterns in communication by observing and reading about how whales communicate.

Strategy
Direct students to watch the video *Song of Whales*. Once finished, allow time for students to share information that surprised them in pairs, and then call on a few students to share with the class. Next, ask students what questions they still have about whale communication. Record students' questions on the board or chart paper. These will be used for reflection after reading the text.

Encourage students to read the passage with a partner, alternating readers each paragraph. After each paragraph is read, the student who is listening tells the main idea of the paragraph. Students highlight the facts that help them better understand how whales communicate.

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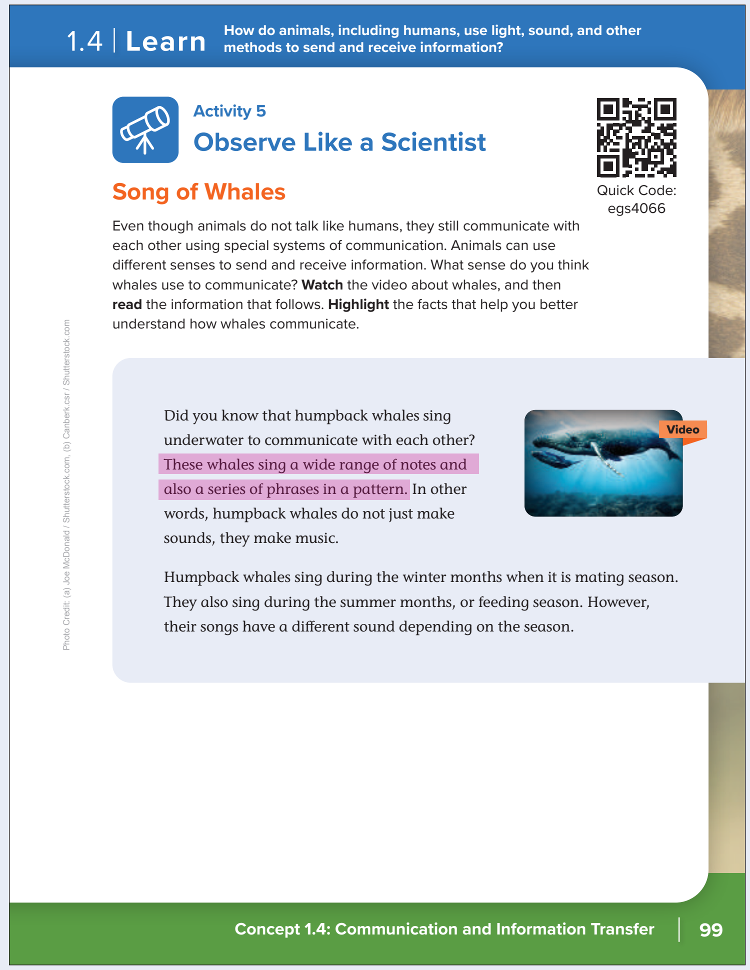

1.4 | Learn How do animals, including humans, use light, sound, and other methods to send and receive information?

Activity 5
Observe Like a Scientist

Song of Whales

Quick Code: egs4066

Even though animals do not talk like humans, they still communicate with each other using special systems of communication. Animals can use different senses to send and receive information. What sense do you think whales use to communicate? **Watch** the video about whales, and then **read** the information that follows. **Highlight** the facts that help you better understand how whales communicate.

Did you know that humpback whales sing underwater to communicate with each other? These whales sing a wide range of notes and also a series of phrases in a pattern. In other words, humpback whales do not just make sounds, they make music.

Video

Humpback whales sing during the winter months when it is mating season. They also sing during the summer months, or feeding season. However, their songs have a different sound depending on the season.

Photo Credit: (a) Joe McDonald / Shutterstock.com, (b) Canberk.csr / Shutterstock.com

Concept 1.4: Communication and Information Transfer | 99

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Activity 5
Observe Like a Scientist
Song of Whales

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Photo Credit: Canberk.csr / Shutterstock.com

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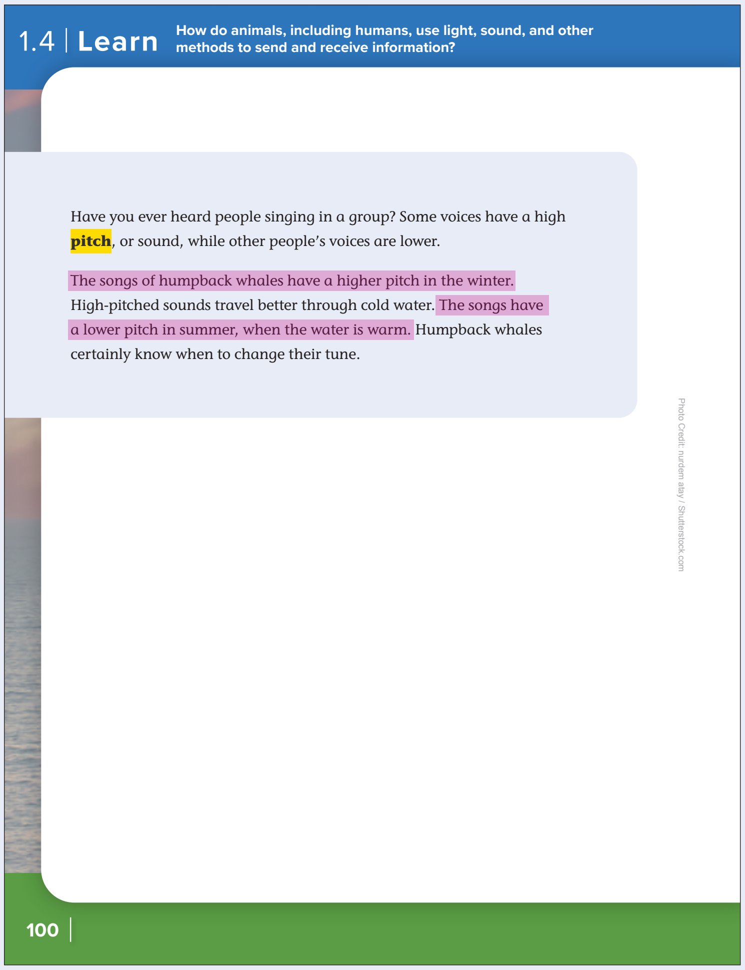

1.4 | **Learn** How do animals, including humans, use light, sound, and other methods to send and receive information?

Have you ever heard people singing in a group? Some voices have a high **pitch**, or sound, while other people's voices are lower.

The songs of humpback whales have a higher pitch in the winter. High-pitched sounds travel better through cold water. The songs have a lower pitch in summer, when the water is warm. Humpback whales certainly know when to change their tune.

Photo Credit: nurdem atay / Shutterstock.com

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Lesson 2, *continued*

Lead a group discussion about how the text helped students better understand the video. To close the activity, refer students back to the list of questions created after watching the video. Ask if any questions were answered in the text. Add any new questions that students now wonder. Encourage students to investigate the answers to these questions on their own.

Lesson 2, *continued*

How Do We Transfer Information?

Activity 6
Analyze Like a Scientist

20 min

Transferring Information

Purpose
In this activity, students connect how human senses collect and process information to ways that humans also use senses to transmit information.

Instructional Focus
In this activity, students analyze text to identify ways that information is transferred using patterns.

Life Skills **Critical Thinking**

Strategy
Flash the lights off and on to get students' attention. Then, hold up a copy of the student book and gesture to indicate that they should turn to the correct page. Do all of this without giving any verbal instructions.

ASK *How did I communicate and what senses did you use to understand me?*
Visually; we use sight.

Direct students to read the text and mark it as follows:

- blue highlighting = I do not understand.
- yellow highlighting = That is interesting.

Ask students to think about a code they have experienced. Encourage students to reflect on their experience with codes by asking probing questions, such as: *How well do you think that code worked? What senses were necessary to understand that code?*

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How Do We Transfer Information?

Activity 6
Analyze Like a Scientist

Quick Code: egs4068

Transferring Information

We use our senses of sight, touch, taste, hearing, and smell to collect information about the world around us. The senses can also be used to communicate, or share information, with others. Imagine your friend is smiling at you. Which sense do you use to understand they are happy? **Read** the text. As you read, **highlight** anything you do not understand with a blue highlighter and anything you find interesting with a yellow highlighter.

Transferring Information

Your sense organs collect information about your environment and send it to your brain. Examples include your ears detecting sound energy and your eyes using light energy to gather information. For a moment, think about all the different kinds of information that you receive through your eyes. Your eyes detect light. This means they can detect signals that travel very fast over different distances, such as your friend waving from across a room, a traffic signal, or a rescue flare. In the past, people used signal fires to communicate over distances of many kilometers. Many backcountry hikers carry mirrors that they can flash to attract the attention of rescue helicopters.

Life Skills I can identify problems.

Concept 1.4: Communication and Information Transfer | 101

Photo Credit: Mongolka / Shutterstock.com

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Activity 6
Analyze Like a Scientist
Transferring Information

Quick Code:
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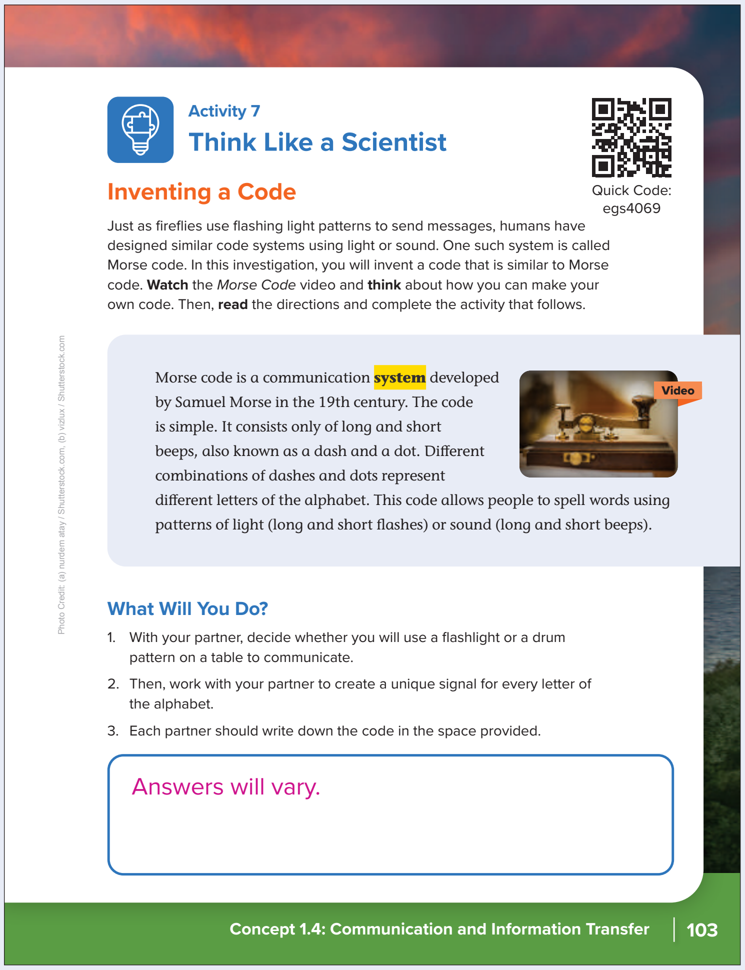

Activity 7

Think Like a Scientist

Quick Code: egs4069

Inventing a Code

Just as fireflies use flashing light patterns to send messages, humans have designed similar code systems using light or sound. One such system is called Morse code. In this investigation, you will invent a code that is similar to Morse code. **Watch** the *Morse Code* video and **think** about how you can make your own code. Then, **read** the directions and complete the activity that follows.

Morse code is a communication **system** developed by Samuel Morse in the 19th century. The code is simple. It consists only of long and short beeps, also known as a dash and a dot. Different combinations of dashes and dots represent different letters of the alphabet. This code allows people to spell words using patterns of light (long and short flashes) or sound (long and short beeps).

Video

What Will You Do?

1. With your partner, decide whether you will use a flashlight or a drum pattern on a table to communicate.
2. Then, work with your partner to create a unique signal for every letter of the alphabet.
3. Each partner should write down the code in the space provided.

Answers will vary.

Concept 1.4: Communication and Information Transfer | 103

Photo Credit: vizlux / Shutterstock.com

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Activity 7
Think Like a Scientist
Inventing a Code

Quick Code:
egst4069

Lesson 3

Activity 7
Think Like a Scientist

45 min

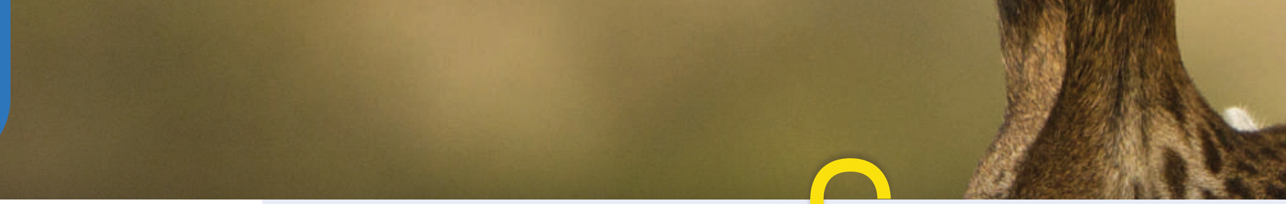
Inventing a Code

Purpose

In this activity, students investigate an example of how humans use signals to send and receive information. Then, students experience signals first-hand using light and sound to communicate.

Instructional Focus

In this activity, students use patterns in light or sound to invent a unique code that they use to transfer information. Then, students identify how their code could be improved.



Activity Activator

In this activity, students will invent a code similar to Morse code. Students will use a flashlight or drum a pattern on a table to send and receive messages from across the room. This activity will help them gain an understanding of communication systems across distance.

Explain that Morse code is a communication system developed by Samuel Morse in the 19th century. It is used to communicate across distances along wires, using a code made of pulses of electric current that the receiver turns into clicks or beeps. The code uses only long and short beeps (dashes and dots), with different combinations of beeps standing for the different letters of the alphabet. Explain that students will invent their own codes similar to Morse code for communicating across the room without speaking.

To further engage students, watch the *Morse Code* video and follow up with questions and discussion by students.

Activity Procedure: What Will You Do?

Part 1: Develop the Code Procedure

Divide students into pairs. Have each pair decide whether they will use a flashlight or a drum pattern on a table to communicate. Provide each pair with their chosen item.

Students should create their code together. Remind students that they must have a unique signal for every letter of the alphabet. Both students in each pair should write down the code on a sheet of notebook paper: one for the sender to use, and one for the receiver to use.

Materials List (per group)

- Flashlight
- Batteries, for flashlight
- Notebook paper
- Pencils

Safety

- Follow all lab safety guidelines.
- Do not eat or drink anything in the lab.

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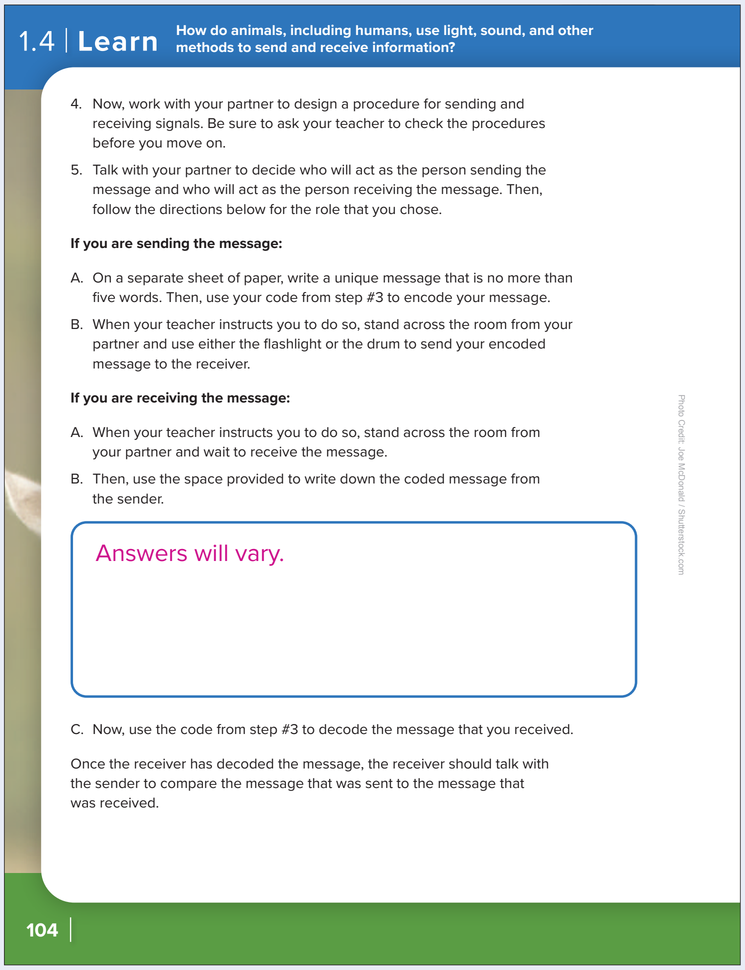

1.4 | **Learn** **How do animals, including humans, use light, sound, and other methods to send and receive information?**

4. Now, work with your partner to design a procedure for sending and receiving signals. Be sure to ask your teacher to check the procedures before you move on.
5. Talk with your partner to decide who will act as the person sending the message and who will act as the person receiving the message. Then, follow the directions below for the role that you chose.

If you are sending the message:

A. On a separate sheet of paper, write a unique message that is no more than five words. Then, use your code from step #3 to encode your message.

B. When your teacher instructs you to do so, stand across the room from your partner and use either the flashlight or the drum to send your encoded message to the receiver.

If you are receiving the message:

A. When your teacher instructs you to do so, stand across the room from your partner and wait to receive the message.

B. Then, use the space provided to write down the coded message from the sender.

Answers will vary.

C. Now, use the code from step #3 to decode the message that you received.

Once the receiver has decoded the message, the receiver should talk with the sender to compare the message that was sent to the message that was received.

Photo Credit: Joe McDonald / Shutterstock.com

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Lesson 3, *continued*

Part 2: Send Signals

Ask advanced students to design a procedure for sending and receiving signals. Check procedures before students begin.

For on-level and approaching-level students, have them choose one student to be the sender and the other to be the receiver. Position the sender on one side of the room and the receiver on the other. Be sure they can clearly see each other. If the room is very bright, you may need to dim the lights for pairs using the flashlight.

Tell the sender to write a message on a sheet of paper. The message should be unique (i.e., do not create a single message every pair will use) and brief (no more than five words). Then, the sender should encode the message using the code the pair devised. The sender should then use the flashlight or drum to send the message to the receiver. The receiver should write down the code he or she receives, and then decode it according to the sheet.

NOTE: If the pair is using a drum, ensure they are the only ones sending and receiving a message at the time. If multiple pairs use drums at the same time, it will be difficult for them to determine which sounds are theirs and which are from other pairs.

Once the receiver has decoded the message, bring the two students back together. Have the receiver check his or her message against the one the sender wrote down.

Repeat this procedure for the other pairs. Note that several pairs using flashlights can transmit their codes simultaneously, but only one pair of students using the drum may transmit at a time.

Lesson 3, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *Did your message make it from your sender to your receiver correctly? If not, what went wrong?*
  Students may have incorrectly sent signals or incorrectly interpreted them. Their code may have included the same encoding for more than one letter. They may have made other mistakes. Some students may have been able to interpret the message despite mistakes such as these.

- *What sense did you use to receive your code?*
  Students who used the flashlight should indicate that they used sight. Students who used the drum should indicate they used hearing.

- *What would you do to improve your code for future use?*
  Student answers will vary. They may say they would simplify their code, or they may say they would make the letters more distinct. Some students may wish they had used the opposite device (students who used a drum may wish to use a flashlight, and vice versa).

Differentiation

APPROACHING LEARNERS

Ask students to think of situations in which Morse code would be necessary to communicate. What are the benefits to using a code? When would a new code need to be used?

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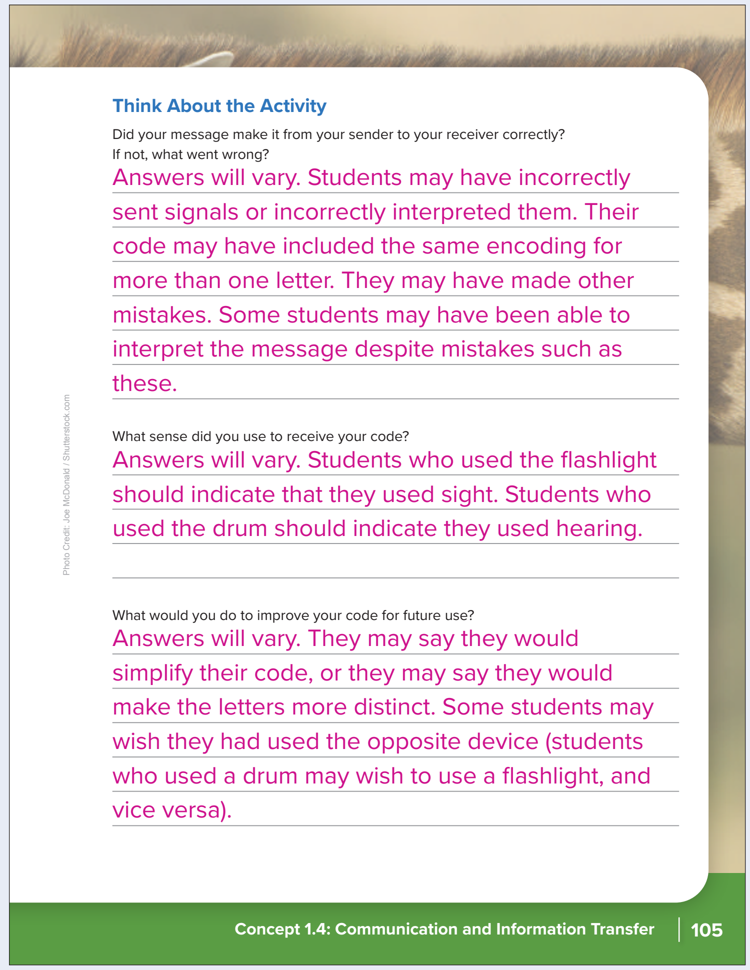

Think About the Activity

Did your message make it from your sender to your receiver correctly? If not, what went wrong?

Answers will vary. Students may have incorrectly sent signals or incorrectly interpreted them. Their code may have included the same encoding for more than one letter. They may have made other mistakes. Some students may have been able to interpret the message despite mistakes such as these.

What sense did you use to receive your code?

Answers will vary. Students who used the flashlight should indicate that they used sight. Students who used the drum should indicate they used hearing.

What would you do to improve your code for future use?

Answers will vary. They may say they would simplify their code, or they may say they would make the letters more distinct. Some students may wish they had used the opposite device (students who used a drum may wish to use a flashlight, and vice versa).

Photo Credit: Joe McDonald / Shutterstock.com

Concept 1.4: Communication and Information Transfer | 105

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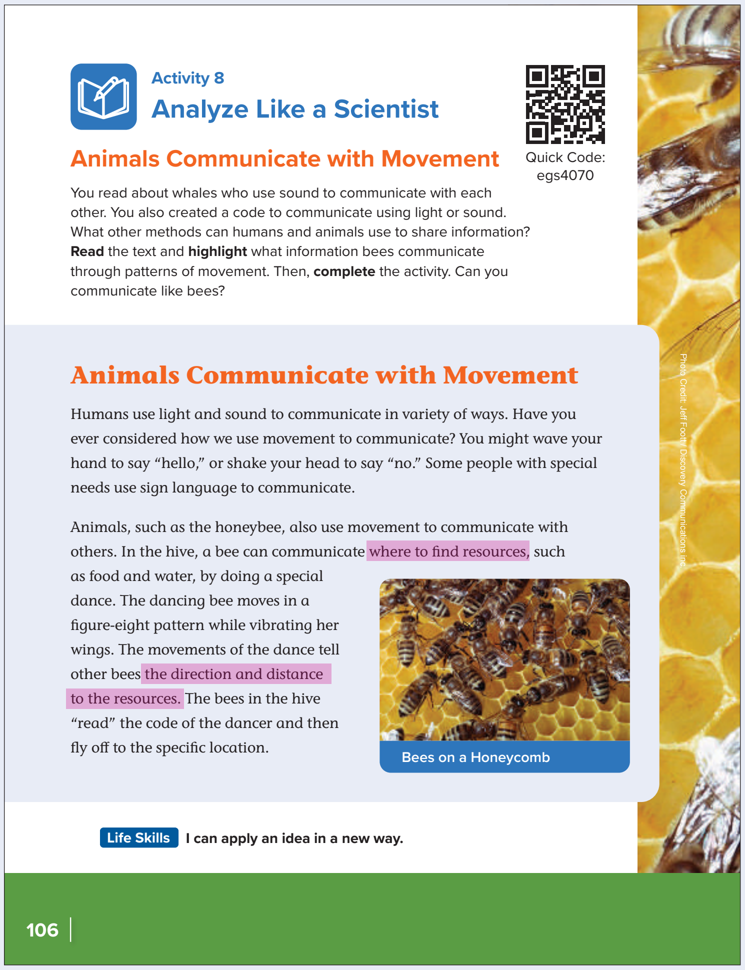

Activity 8

Analyze Like a Scientist

Animals Communicate with Movement

Quick Code: egs4070

You read about whales who use sound to communicate with each other. You also created a code to communicate using light or sound. What other methods can humans and animals use to share information? **Read** the text and **highlight** what information bees communicate through patterns of movement. Then, **complete** the activity. Can you communicate like bees?

Animals Communicate with Movement

Humans use light and sound to communicate in variety of ways. Have you ever considered how we use movement to communicate? You might wave your hand to say "hello," or shake your head to say "no." Some people with special needs use sign language to communicate.

Animals, such as the honeybee, also use movement to communicate with others. In the hive, a bee can communicate where to find resources, such as food and water, by doing a special dance. The dancing bee moves in a figure-eight pattern while vibrating her wings. The movements of the dance tell other bees the direction and distance to the resources. The bees in the hive "read" the code of the dancer and then fly off to the specific location.

Bees on a Honeycomb

Life Skills I can apply an idea in a new way.

106

Photo Credit: Jeff Foott / Discovery Communications inc.

DIGITAL

Activity 8

Analyze Like a Scientist

Animals Communicate with Movement

Quick Code: egst4070

Lesson 4

Activity 8

Analyze Like a Scientist

20 min

Animals Communicate with Movement

Purpose

This activity returns to communication in the animal world and introduces a new method of transferring information beyond using light and sound patterns: movement. Students begin to compare animal and human communication systems.

Instructional Focus

In this activity, students analyze text to identify ways that information is transferred using patterns. Then, students use patterns in movement to analyze a code in order to transfer information.

Life Skills **Creativity**

Strategy

Ask students to read the passage Animals Communicate with Movement.

ASK *How does the way honeybees communicate compare to the way humans communicate?* *Honeybees and humans use movement to communicate. Honeybees use movement to communicate directions to resources. Humans use movements to communicate, including sign language or simple gestures.*

Lesson 4, *continued*

Activity Activator

In this activity, students will analyze a code similar to the waggle dance honeybees use to communicate. Students watch a student volunteer do a dance that communicates where in the room they should go to find a hidden flower. This activity will help students gain an understanding of how movement can be used to code and transfer information to others.

Prior to reading the text Animals Communicate with Movement, ask students to think about ways they can communicate with each other without using light or sound.

Activity Procedure: What Will You Do?

Prior to the lesson, draw a picture of a flower on a small piece of paper. Ask for a student volunteer to come up to the front of the class. This student will be the bee scout. While the rest of the students close their eyes, ask the volunteer scout to hide the flower somewhere in the classroom. Once the volunteer scout is back at the front of the classroom, students open their eyes. Instruct the volunteer scout to perform a waggle dance to tell the other students where the flower is hidden. The volunteer should use the Honeybee Dance Key for the movements.

The other students in class use the key to interpret what the movements show. When the volunteer is finished, ask a student in the class to follow the directions given by the volunteer scout and go to that spot in the classroom to find the hidden flower.

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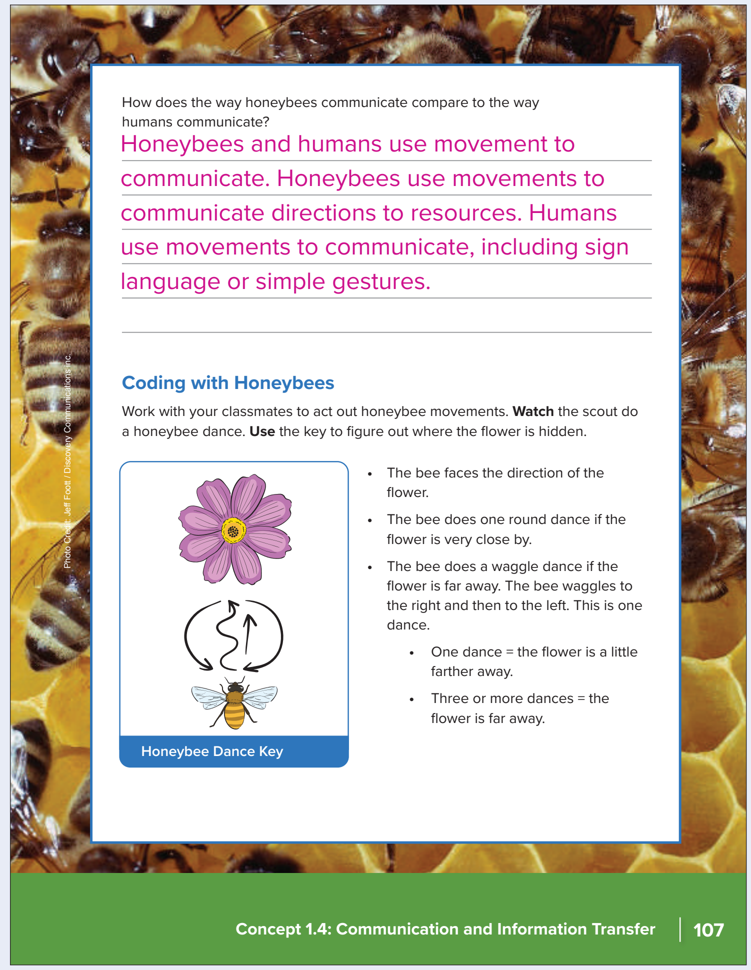

How does the way honeybees communicate compare to the way humans communicate?

Honeybees and humans use movement to communicate. Honeybees use movements to communicate directions to resources. Humans use movements to communicate, including sign language or simple gestures.

Coding with Honeybees

Work with your classmates to act out honeybee movements. **Watch** the scout do a honeybee dance. **Use** the key to figure out where the flower is hidden.

Honeybee Dance Key

- The bee faces the direction of the flower.
- The bee does one round dance if the flower is very close by.
- The bee does a waggle dance if the flower is far away. The bee waggles to the right and then to the left. This is one dance.
  - One dance = the flower is a little farther away.
  - Three or more dances = the flower is far away.

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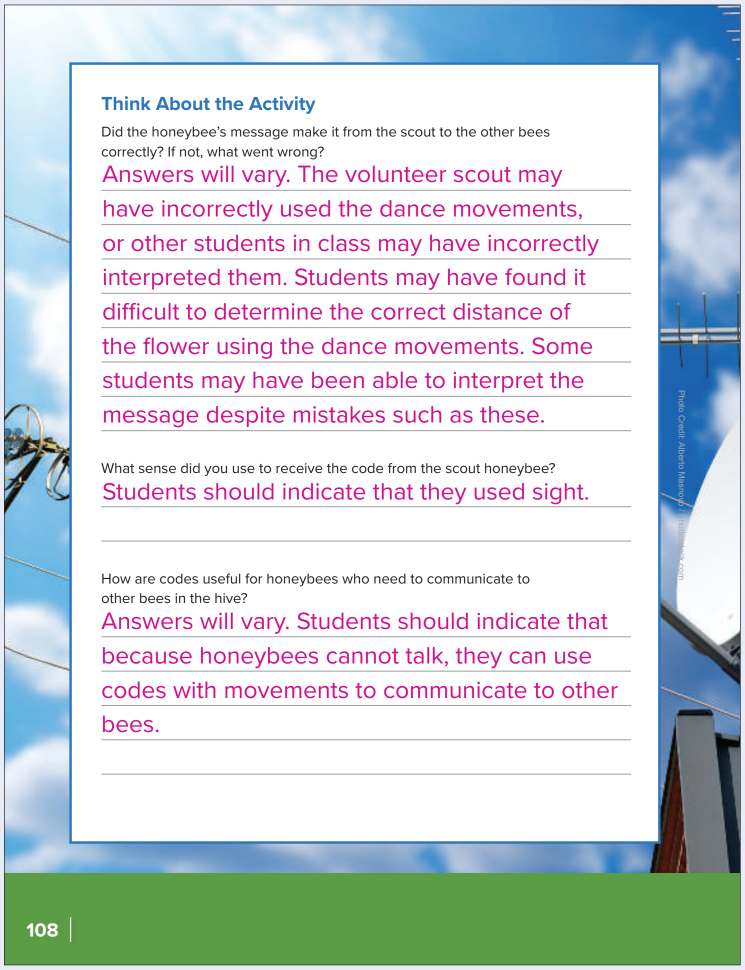

Think About the Activity

Did the honeybee's message make it from the scout to the other bees correctly? If not, what went wrong?

Answers will vary. The volunteer scout may have incorrectly used the dance movements, or other students in class may have incorrectly interpreted them. Students may have found it difficult to determine the correct distance of the flower using the dance movements. Some students may have been able to interpret the message despite mistakes such as these.

What sense did you use to receive the code from the scout honeybee?

Students should indicate that they used sight.

How are codes useful for honeybees who need to communicate to other bees in the hive?

Answers will vary. Students should indicate that because honeybees cannot talk, they can use codes with movements to communicate to other bees.

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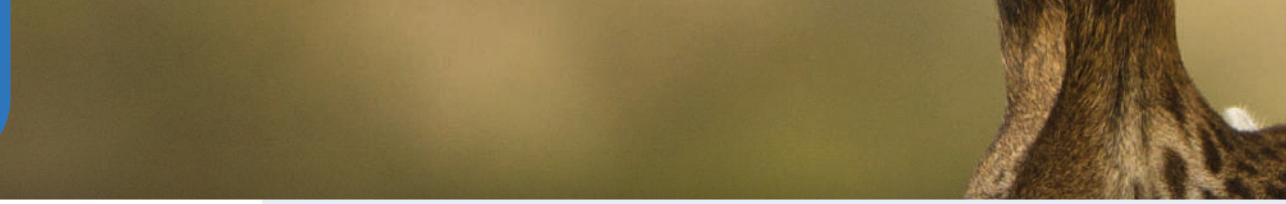
Lesson 4, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *Did the honeybee's message make it from the scout to the other bees correctly? If not, what went wrong?*
  Answers will vary. The volunteer scout may have incorrectly used the dance movements, or other students in class may have incorrectly interpreted them. Students may have found it difficult to determine the correct distance of the flower using the dance movements. Some students may have been able to interpret the message despite mistakes such as these.
- *What sense did you use to receive the code from the scout honeybee?*
  Students should indicate that they used sight.
- *How are codes useful for honeybees who need to communicate to other bees in the hive?*
  Answers will vary. Students should indicate that because honeybees cannot talk, they can use codes with movements to communicate to other bees.



Lesson 4, *continued*

What Are Communication Systems, and How Do We Use Them?

Activity 9
Analyze Like a Scientist

10 min

Communication Systems

Purpose

During the last several activities, students have focused on the ways animals and humans use their senses to communicate specific messages with each other. In this activity, students consider the complex communication systems humans have designed. Students draw on their understanding of how the components of the nervous system work together to receive and process information.

Instructional Focus

In this activity, students explore individual components of systems that humans use to facilitate communication.

Strategy

After reading the text, have students share their own definition of a *system.* Then, have students tell a partner what they already know about communication systems. Students may be familiar with satellite dishes or communication towers as they relate to mobile phone coverage. Facilitate a class discussion in which students share their ideas and make a list of questions they have about components of communication systems.

Explain that in the following activities, students will be exploring in more detail similarities and differences between how animals and humans use communication systems.

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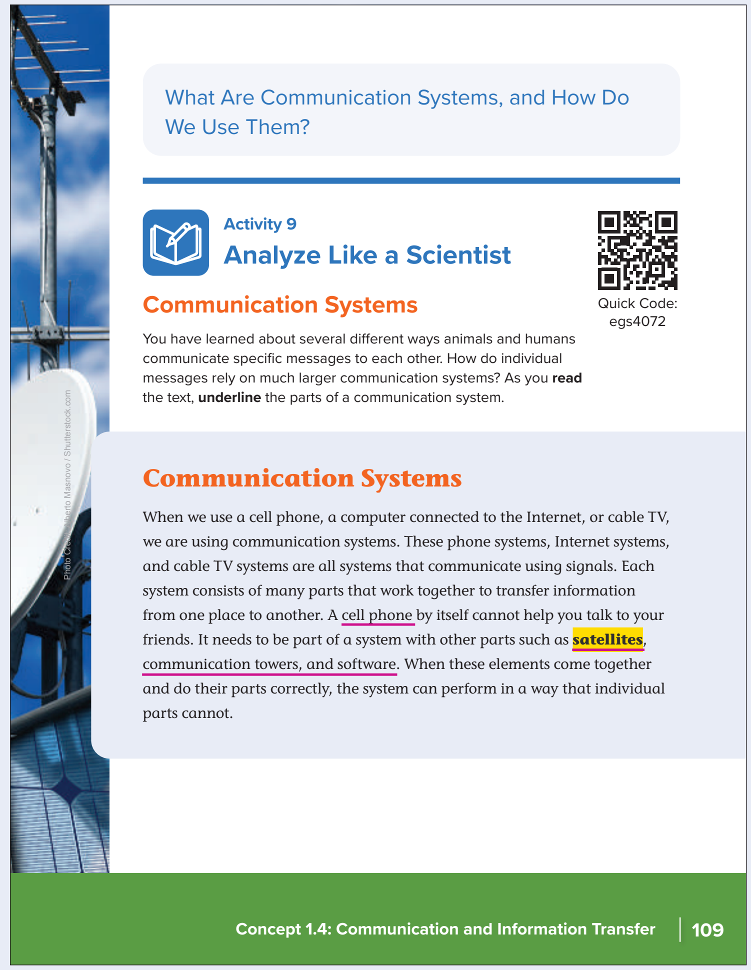
What Are Communication Systems, and How Do We Use Them?

Activity 9
Analyze Like a Scientist

Communication Systems

Quick Code: egs4072

You have learned about several different ways animals and humans communicate specific messages to each other. How do individual messages rely on much larger communication systems? As you **read** the text, **underline** the parts of a communication system.

Communication Systems

When we use a cell phone, a computer connected to the Internet, or cable TV, we are using communication systems. These phone systems, Internet systems, and cable TV systems are all systems that communicate using signals. Each system consists of many parts that work together to transfer information from one place to another. A cell phone by itself cannot help you talk to your friends. It needs to be part of a system with other parts such as **satellites**, communication towers, and software. When these elements come together and do their parts correctly, the system can perform in a way that individual parts cannot.

Concept 1.4: Communication and Information Transfer | 109

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Activity 9
Analyze Like a Scientist
Communication Systems

Quick Code:
egst4072

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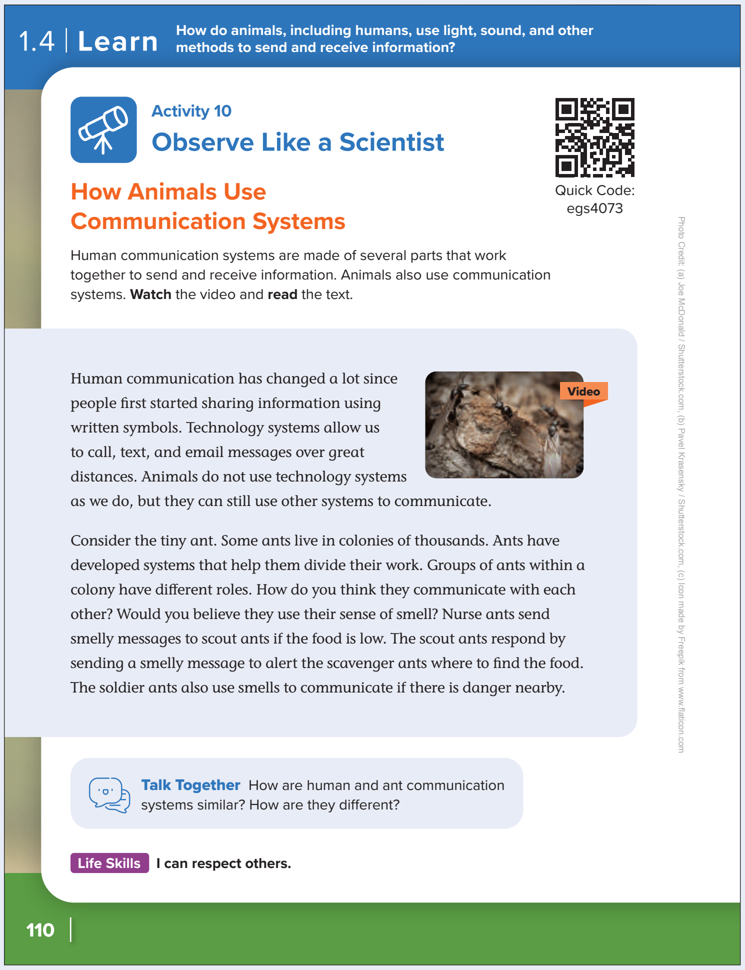

1.4 | **Learn** How do animals, including humans, use light, sound, and other methods to send and receive information?

Activity 10

Observe Like a Scientist

How Animals Use Communication Systems

Quick Code: egs4073

Human communication systems are made of several parts that work together to send and receive information. Animals also use communication systems. **Watch** the video and **read** the text.

Human communication has changed a lot since people first started sharing information using written symbols. Technology systems allow us to call, text, and email messages over great distances. Animals do not use technology systems as we do, but they can still use other systems to communicate.

Video

Consider the tiny ant. Some ants live in colonies of thousands. Ants have developed systems that help them divide their work. Groups of ants within a colony have different roles. How do you think they communicate with each other? Would you believe they use their sense of smell? Nurse ants send smelly messages to scout ants if the food is low. The scout ants respond by sending a smelly message to alert the scavenger ants where to find the food. The soldier ants also use smells to communicate if there is danger nearby.

Talk Together How are human and ant communication systems similar? How are they different?

Life Skills I can respect others.

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Photo Credit: Pavel Krasensky / Shutterstock.com

DIGITAL

Activity 10

Observe Like a Scientist

How Animals Use Communication Systems

Quick Code: egst4073

Activity 10

Observe Like a Scientist

15 min

How Animals Use Communication Systems

Purpose

In this activity, students compare a communication system used by animals to communication systems designed by humans.

Instructional Focus

In this activity, students obtain, evaluate, and communicate information about how animals use communication systems.

Life Skills **Sharing**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before watching the video, ask students to list examples of what they already know about how various animals communicate. Students may list examples previously introduced in the concept or unit or examples from personal experience or prior knowledge.

Show students the video *Ant Communication* and instruct them to read the text.

In small groups, challenge students to construct an explanation about how animal communication systems are similar to the communication systems humans use. Encourage groups to share their explanations with the whole class to build a class explanation.

Lesson 5

Scientific Explanation

Activity 11
Record Evidence Like a Scientist

25 min

Firefly Light Show

Purpose

In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students construct an explanation about how communication systems are used to transfer information.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Display the investigative phenomenon of the *Firefly Light Show* video and the Can You Explain? question. Students may also wish to to review the text Firefly Light Show. Ask students to use their experiences in Learn to consider how to explain the phenomenon. Once students have decided how best to describe the phenomenon, direct them to discuss their ideas with the class or a partner.

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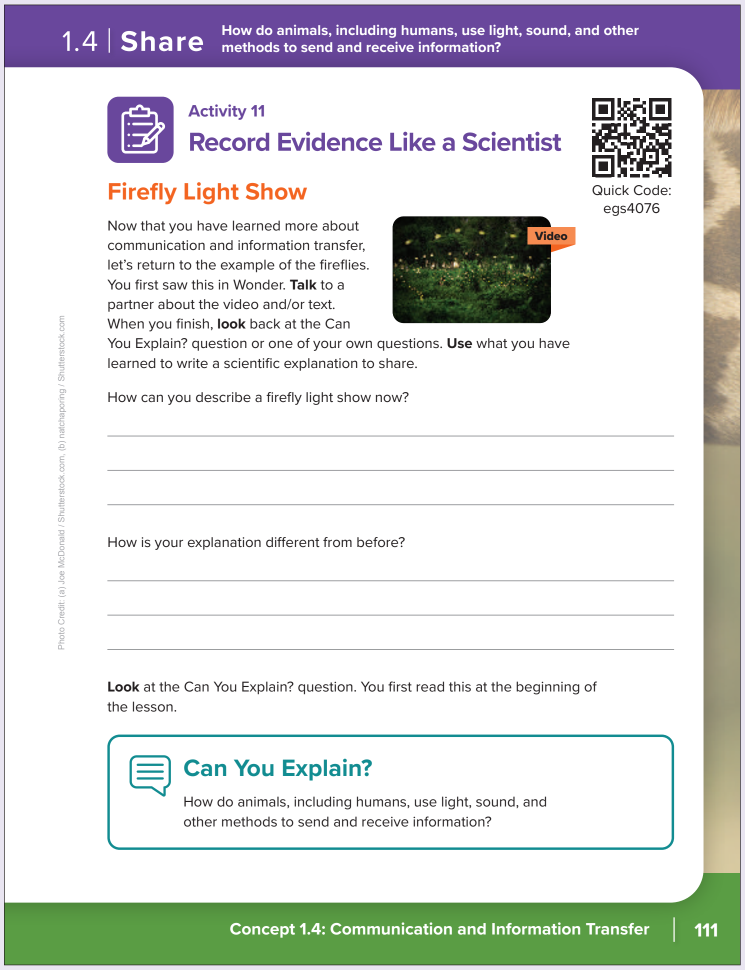

1.4 | Share How do animals, including humans, use light, sound, and other methods to send and receive information?

Activity 11

Record Evidence Like a Scientist

Quick Code: egs4076

Firefly Light Show

Video

Now that you have learned more about communication and information transfer, let's return to the example of the fireflies. You first saw this in Wonder. **Talk** to a partner about the video and/or text. When you finish, **look** back at the Can You Explain? question or one of your own questions. **Use** what you have learned to write a scientific explanation to share.

How can you describe a firefly light show now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this at the beginning of the lesson.

Can You Explain?

How do animals, including humans, use light, sound, and other methods to send and receive information?

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Activity 11
Record Evidence Like a Scientist
Firefly Light Show

Quick Code:
egst4076

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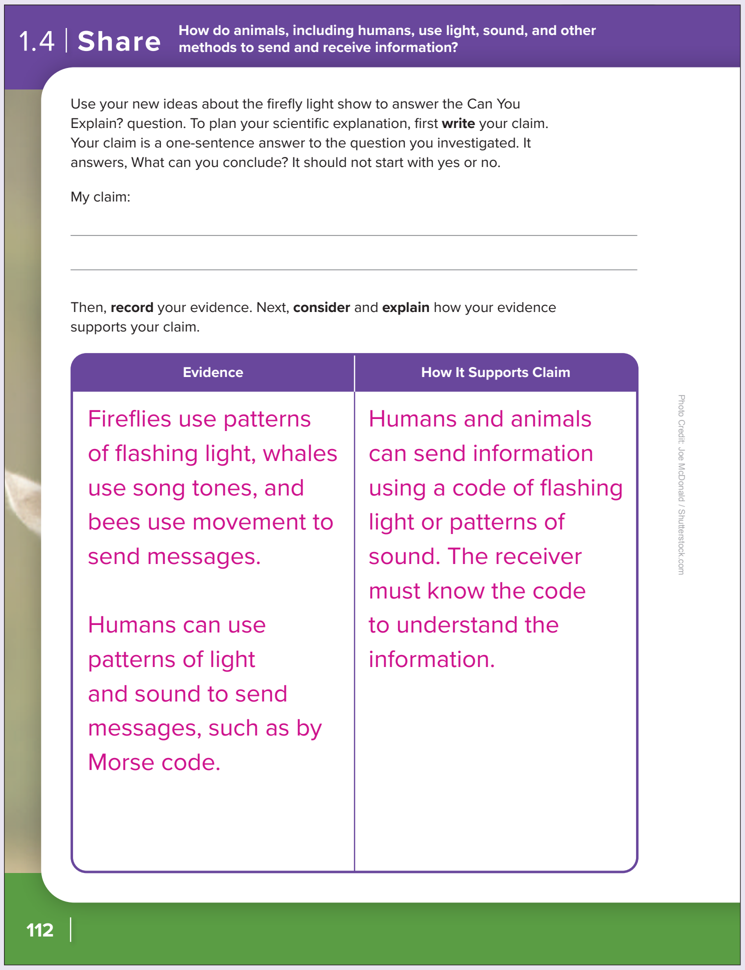

1.4 | **Share** How do animals, including humans, use light, sound, and other methods to send and receive information?

Use your new ideas about the firefly light show to answer the Can You Explain? question. To plan your scientific explanation, first **write** your claim. Your claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with yes or no.

My claim:

Then, **record** your evidence. Next, **consider** and **explain** how your evidence supports your claim.

Evidence	How It Supports Claim
Fireflies use patterns of flashing light, whales use song tones, and bees use movement to send messages. Humans can use patterns of light and sound to send messages, such as by Morse code.	Humans and animals can send information using a code of flashing light or patterns of sound. The receiver must know the code to understand the information.

Photo Credit: Joe McDonald / Shutterstock.com

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Lesson 5, *continued*

ASK *How can this explanation help you answer the Can You Explain? question?*

Have students generate a scientific explanation to answer the Can You Explain? question.

Can You Explain?

How do animals, including humans, use light, sound, and other methods to send and receive information?

As students would have already reviewed sample scientific explanations in earlier concepts, they should be familiar with the claim-and-evidence framework. You may want to review the following:

A **claim** is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with yes or no.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use information from text, video, or data that supports the claim. Leave out information that doesn't support the claim.

After providing scaffolding to the students, for those students able to do so, allow them to construct a full scientific explanation. Students can write, draw, or orally describe their claim and evidence.

Lesson 5, *continued*

Differentiation

Because of cultural, linguistic, and economic differences, not all students may be familiar with the domain-specific words commonly used in science. As a result, some students will encounter difficulty or show a lack of confidence when reporting on their scientific explanations or engaging in scientific argument. Classroom instruction should be adapted to meet the needs of these students. Most importantly, students should be provided with a supportive learning environment that respects the discussion of their ideas.

Sample student response:
Humans use light and sound to send and receive information using different communication systems. Patterns of light or sound are used to send messages. We created our own code using a flashlight to send a message across a room. Others used sound patterns to send a message. Animals also use light and sound as well as movement and smell to send and receive information. For example, fireflies flash lights to warn others of predators. Bees use a waggle dance to tell others where to find food. Ants release scents to guide other ants to find food and warn of enemies. Whether humans or animals, the receiver of the message must know the pattern or code to understand the information being sent.

Teacher Reflection

- How has my students' construction of scientific explanations improved from earlier in the course?
- How did I provide scaffolding for students to construct their scientific explanations?
- How do I know my students are ready to apply the core content knowledge to another context?

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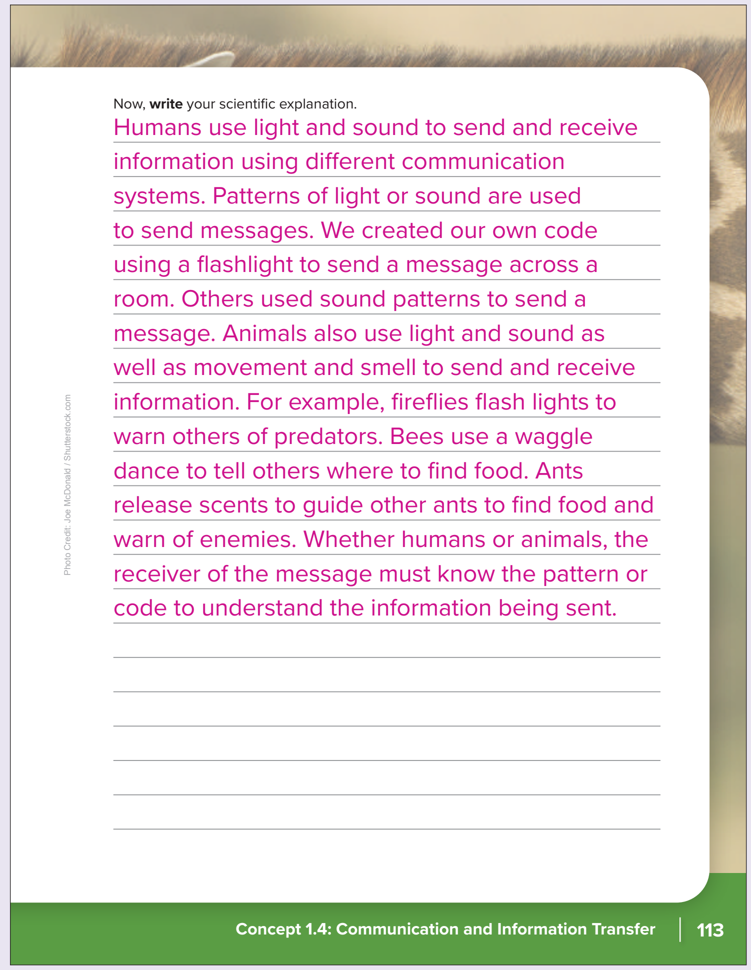
Now, **write** your scientific explanation.

Humans use light and sound to send and receive information using different communication systems. Patterns of light or sound are used to send messages. We created our own code using a flashlight to send a message across a room. Others used sound patterns to send a message. Animals also use light and sound as well as movement and smell to send and receive information. For example, fireflies flash lights to warn others of predators. Bees use a waggle dance to tell others where to find food. Ants release scents to guide other ants to find food and warn of enemies. Whether humans or animals, the receiver of the message must know the pattern or code to understand the information being sent.

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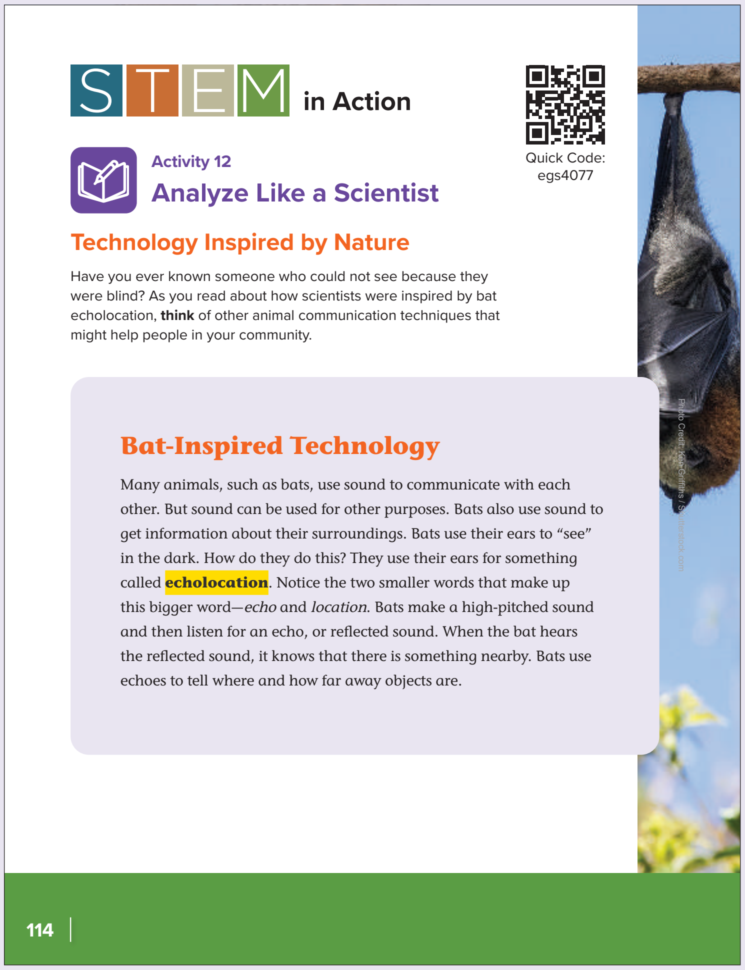

STEM in Action

Quick Code: egs4077

Activity 12

Analyze Like a Scientist

Technology Inspired by Nature

Have you ever known someone who could not see because they were blind? As you read about how scientists were inspired by bat echolocation, **think** of other animal communication techniques that might help people in your community.

Bat-Inspired Technology

Many animals, such as bats, use sound to communicate with each other. But sound can be used for other purposes. Bats also use sound to get information about their surroundings. Bats use their ears to "see" in the dark. How do they do this? They use their ears for something called **echolocation**. Notice the two smaller words that make up this bigger word—*echo* and *location*. Bats make a high-pitched sound and then listen for an echo, or reflected sound. When the bat hears the reflected sound, it knows that there is something nearby. Bats use echoes to tell where and how far away objects are.

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Photo Credit: Anastasia Shukeyych / Discovery Education

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Activity 12

Analyze Like a Scientist

Technology Inspired by Nature

Quick Code: egst4077

Lesson 5, *continued*

STEM in Action

Activity 12

Analyze Like a Scientist

20 min

Technology Inspired by Nature

Purpose

This activity connects the scientific ideas of animals communicating using senses to real-world applications. Students will make connections between bat echolocation and assistive devices for blind humans.

Instructional Focus

In this activity, students obtain and evaluate information about how animal communication has inspired new technology.

Strategy

Instruct students to read the passage Bat-Inspired Technology. Allow students to read alone or in pairs depending on need for literacy support.

ENTREPRENEURSHIP

Entrepreneurs explore the world and identify problems that need to be solved through their own experiences and by learning from others' experiences. As students read about this technology inspired by nature, ask them to identify other communication challenges they and others around them have experienced. Could any of the animal communication systems highlighted in this concept help solve a new challenge?

Lesson 5, *continued*

ASK

- *How did scientists use an animal adaptation to design a new invention?*
  Scientists were inspired by bat echolocation to make a cane for people who cannot see.
- *How are the cane and bat echolocation similar?*
  The cane and bats emit a high-pitched sound that bounces off objects with an echo. The cane and bats then "hear" the echo and can tell how far away objects are.
- *What is one main difference between the cane and bat echolocation?*
  The cane picks up an echo from the sound it emits and changes it into a vibration. The person using the cane feels the vibration and can tell where objects are around them. Bats do not change the echo into vibrations.
- *Think back to how honeybees communicate with each other. How are the cane and the honeybee dance similar?*
  Honeybees make a series of movements and vibrations with their wings to communicate flower location to other bees. The cane makes a series of vibrations to communicate to the person using it where objects around them are located.

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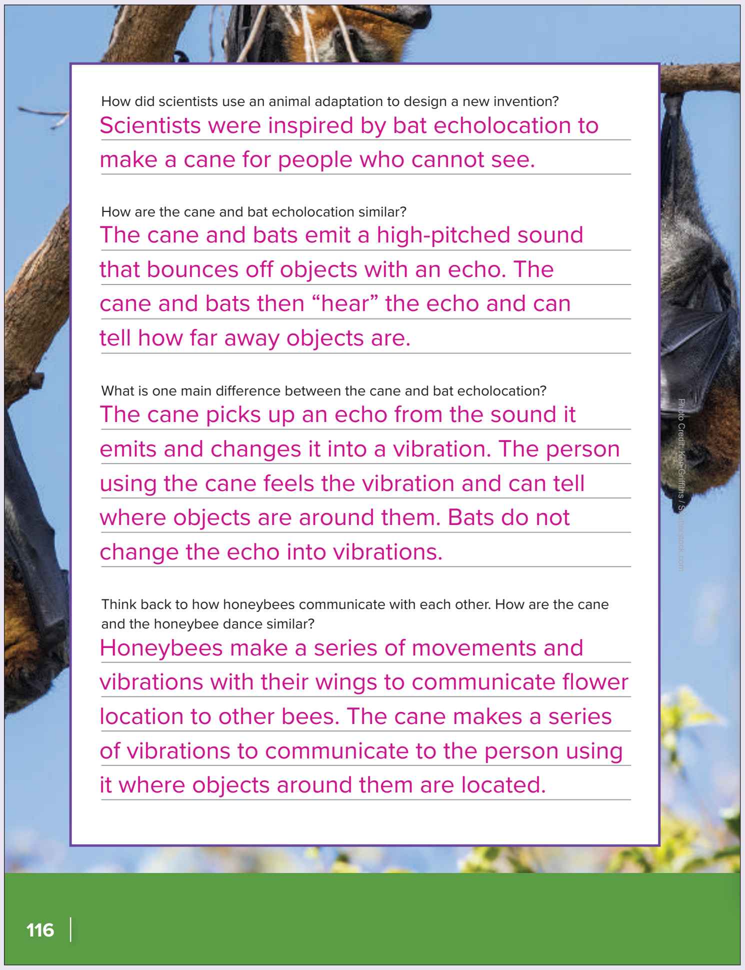

How did scientists use an animal adaptation to design a new invention?

Scientists were inspired by bat echolocation to make a cane for people who cannot see.

How are the cane and bat echolocation similar?

The cane and bats emit a high-pitched sound that bounces off objects with an echo. The cane and bats then "hear" the echo and can tell how far away objects are.

What is one main difference between the cane and bat echolocation?

The cane picks up an echo from the sound it emits and changes it into a vibration. The person using the cane feels the vibration and can tell where objects are around them. Bats do not change the echo into vibrations.

Think back to how honeybees communicate with each other. How are the cane and the honeybee dance similar?

Honeybees make a series of movements and vibrations with their wings to communicate flower location to other bees. The cane makes a series of vibrations to communicate to the person using it where objects around them are located.

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Activity 13

Evaluate Like a Scientist

Quick Code: egs4078

Review: Communication and Information Transfer

Think about what you have learned so far in this concept about how humans and other animals communicate. Animals use a variety of ways to communicate, and humans have a much more complex system of communication. As you review this concept, use the space provided to **summarize** your learning. **Explain** the similarities and differences between how humans and animals communicate. If you have additional questions about communication systems, **write** them here and **share** these with your teacher and classmates.

Student responses will vary.

Talk Together How does your new understanding of communication systems help you better understand bats? Talk to your partner about how you can use your knowledge of adaptations, senses, and communication to get ready for the Unit Project.

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Concept 1.4: Communication and Information Transfer | 117

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Activity 13
Evaluate Like a Scientist
Review: Communication and Information Transfer

Quick Code: egst4078

Lesson 6

Review and Assess

Activity 13

Evaluate Like a Scientist

25 min

Review: Communication and Information Transfer

Purpose

The final activity of the concept asks students to review the ideas presented about how humans and other animals communicate, especially using light and sound.

Instructional Focus

In this activity, students summarize their learning and apply it to the big ideas of the unit.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas. Focus student review on the similarities and differences between how humans and animals communicate, both specific messages and using complex systems.

After reviewing key ideas, encourage students to discuss how they can use this new knowledge to research bats for the Unit Project.

Unit Project

Solve Problems Like a Scientist

65 min

Unit Project: Bat Chat

Instructional Focus

The Unit Project allows students to return to the Anchor Phenomenon for the unit and apply the learning standards for the unit to bat communication.

Life Skills **Accountability**

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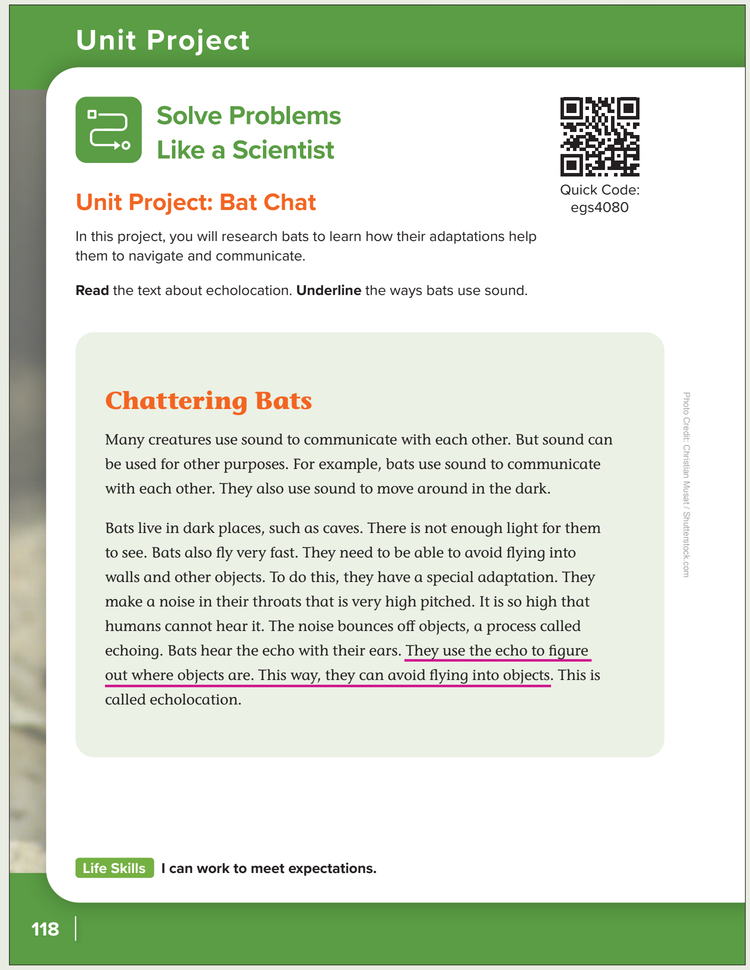

Unit Project

Solve Problems Like a Scientist

Quick Code: egs4080

Unit Project: Bat Chat

In this project, you will research bats to learn how their adaptations help them to navigate and communicate.

Read the text about echolocation. **Underline** the ways bats use sound.

Chattering Bats

Many creatures use sound to communicate with each other. But sound can be used for other purposes. For example, bats use sound to communicate with each other. They also use sound to move around in the dark.

Bats live in dark places, such as caves. There is not enough light for them to see. Bats also fly very fast. They need to be able to avoid flying into walls and other objects. To do this, they have a special adaptation. They make a noise in their throats that is very high pitched. It is so high that humans cannot hear it. The noise bounces off objects, a process called echoing. Bats hear the echo with their ears. They use the echo to figure out where objects are. This way, they can avoid flying into objects. This is called echolocation.

Photo Credit: Christian Musat / Shutterstock.com

Life Skills I can work to meet expectations.

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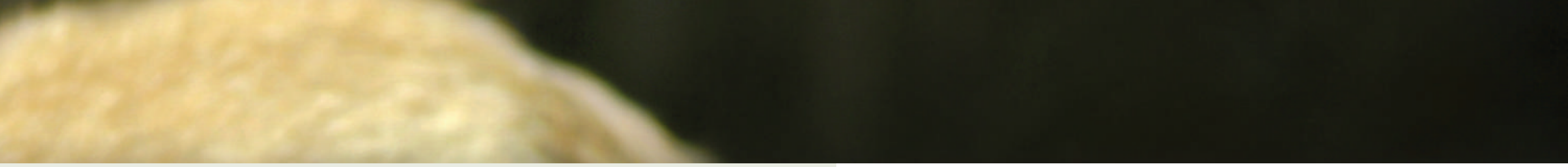
Quick Code: egst4080



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Bats also use echolocation to hunt. They make a noise, and the noise bounces off prey. Bats can find even tiny prey this way. For example, many bats eat mosquitoes. Although mosquitoes are very small, bats can find them with sound.

Bats also communicate with each other using sound. Bats make different sounds that mean different things, just like people communicate with words.

Most of the sounds are too high for humans to hear. Researchers use recording devices that can measure the sound. They have decoded many of the sounds bats make and have found that most of the sounds are arguments. Bats argue almost constantly. They argue about food. They argue about where they get to sleep. They argue about which bats they get to have as mates.

Bat Chat

Photo Credit: (a) Christian Musat / Shutterstock.com, (b) Discovery Communications, Inc.

Unit 1: Living Systems | 119

Unit Project, *continued*

Strategy

Students will research bats and make a model that shows how bats use echolocation. Then, they will use evidence to make a claim as to why it is helpful for bats to have different sounds that mean different things.

Students may complete the project individually or in pairs. You may wish to consider displaying student diagrams around the classroom. Have students compare their own diagrams to those of their classmates.

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Unit Project

Echolocation

Research bats further by using print or online sources. **Learn** about the ways bats have adapted to use sound to navigate, hunt, and communicate. Then, **draw** a diagram of a bat using sound to avoid obstacles and find prey. **Label** all relevant parts of the diagram. Be sure to include the way the sound interacts with the bat, the obstacles, and the prey.

Student diagrams will vary, but they should show sound waves first moving from the bat, then hitting and bouncing off an object, and then returning to the bat.

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Bat Chat

Bats communicate by using different sounds to mean different things, like humans use language. Bats also hunt and fly in the caves where they live, and they do so using echolocation.

Explain why it is helpful for bats to have different sounds that mean different things, given these facts. **Use** a Claim-Evidence chart to organize your thoughts.

Claim

Answers may vary. Bats use different sounds to communicate different messages.

Evidence

Answers will vary.

Unit 1: Living Systems | 121

Interdisciplinary Project

Solve Problems Like a Scientist

135 min

Interdisciplinary Project: To Get to the Other Side

Instructional Focus

The Interdisciplinary Project challenges students to use science, literacy, math, and design skills to find a solution to a real-world problem. This project explores how humans can impact the ecosystems of other living organisms, sometimes prompting behavioral or structural adaptations. The Project is best implemented over at least three lessons, and could be extended to more depending on time available and student interest.

Life Skills **Accountability**

Life Skills **Problem-Solving**

Life Skills **Decision Making**

Project Overview

Each Interdisciplinary Project presents an opportunity for students to use the Engineering Design Process to design an original solution to the problem presented. A fictional story and a non-fiction article set up a challenge and provide students with necessary background information. A multi-step hands-on investigation then leads students through the tasks of brainstorming and sketching designs, deciding on and planning a solution, then building a prototype.

The project *To Get to the Other Side* presents a challenge that is related to the United Nations Sustainable Development Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.

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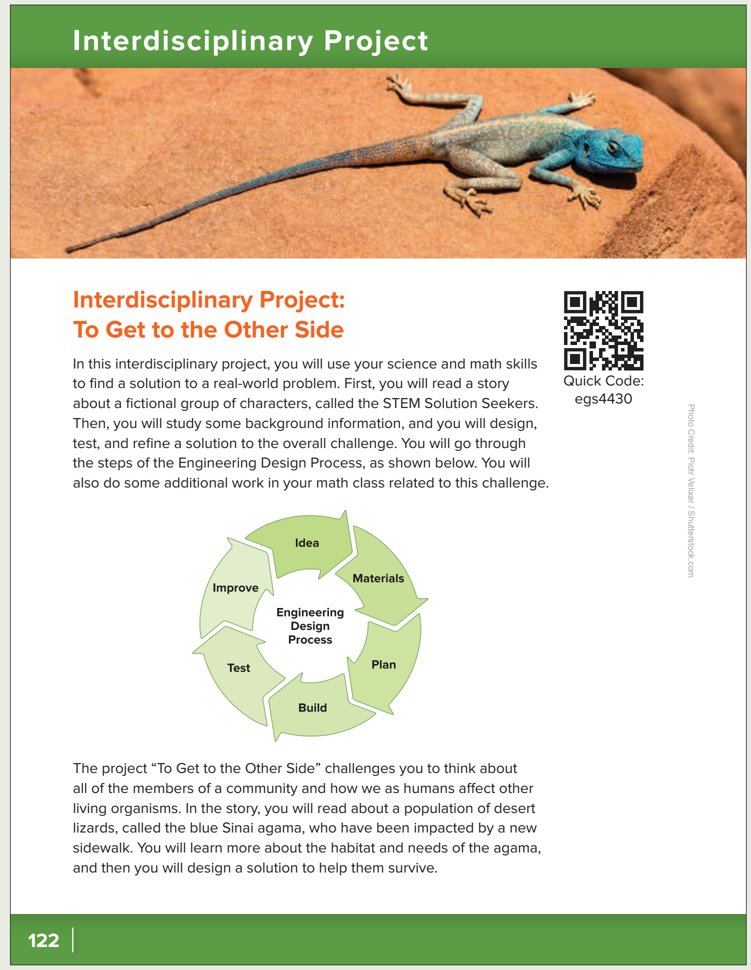

Interdisciplinary Project

Interdisciplinary Project: To Get to the Other Side

Quick Code: egs4430

In this interdisciplinary project, you will use your science and math skills to find a solution to a real-world problem. First, you will read a story about a fictional group of characters, called the STEM Solution Seekers. Then, you will study some background information, and you will design, test, and refine a solution to the overall challenge. You will go through the steps of the Engineering Design Process, as shown below. You will also do some additional work in your math class related to this challenge.

Engineering Design Process
Idea
Materials
Plan
Build
Test
Improve

The project "To Get to the Other Side" challenges you to think about all of the members of a community and how we as humans affect other living organisms. In the story, you will read about a population of desert lizards, called the blue Sinai agama, who have been impacted by a new sidewalk. You will learn more about the habitat and needs of the agama, and then you will design a solution to help them survive.

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Quick Code: egs4430

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To Get to the Other Side

Maher, Laila, and Gil are looking for the Sinai agama lizards that they usually see on their walk home from school. "I can't find any. Where'd they all go?" asks Laila.

"Professor Hassan said there were lots of them here," says Maher. He is using a stick to poke in the sand and gravel at the edge of the sidewalk.

They keep searching but don't find any lizards. As they grow tired of looking, Laila says, "I wonder why we can't find them. I think we need to ask Professor Hassan." Maher and Gil smile as all three start to run down the sidewalk to her house.

Unit 1: Living Systems | 123

Interdisciplinary Project, *continued*

In this project, students consider the needs that people, animals, and plants have within a community. Students analyze their own role in ensuring their community is functional and provides a sustainable environment for all living organisms. In the design challenge, students explore how communities can design alternative walking paths that promote healthy living without negatively impacting the habitats of other living creatures.

Strategy

As a class, read the STEM Solutions Seekers story. Pause after the first paragraph and ask students to brainstorm possible reasons why Maher, Gil, and Laila cannot find the agamas.

Use the story to help students zero in on the impact human actions have on the environment, specifically actions that result from communities growing and changing. The story gives students a context for exploring infrastructure (building) designs that are sustainable for the surrounding ecosystems in addition to the human community.

Encourage students to talk about and relate to the characters and situation in the story.

ASK

- *What was the challenge?*
- *What are the benefits of the new sidewalk?*
- *What do Maher, Gil, and Laila want to do to help the agamas?*
- *Have you ever noticed a change in the types or number of animals you see in a specific place? What do you think caused the change?*

Tell students that in this project they will be helping the STEM Solutions Seekers by designing a sidewalk that meets the needs of both humans and Sinai agama lizards.

Interdisciplinary Project, *continued*

In order to get started, divide students into groups of 4. Groups will begin by reading the article on the Sinai agama to gather more information. As they read, instruct students to highlight important information about agama habitats.

Project Procedure

1. **Review the Challenge** Students read the Challenge description, review the objectives and study the requirements from the school and the needs of the Sinai agama.

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Interdisciplinary Project

Hands-On Investigation

Engineering Your Solution

Challenge

You have been asked to create a solution for a sidewalk design that meets the needs of both humans and Sinai agama lizards. This activity will guide your team through the Engineering Design Process.

Objectives

In this activity, you will . . .

- Review the challenge requirements and assign roles to each member of your team
- Create three or four sketches to brainstorm solutions
- Agree upon one final blueprint for your prototype
- Create a prototype of your solution that helps the Sinai agama return to their habitat

A Desert Agama Habitat

Photo Credit: Laura Dinraths / Shutterstock.com

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Materials List (per group)

- Building materials, such as craft sticks or small pieces of wood
- Construction paper or cardboard
- Pebbles, small rocks, and/or clay
- Sand, small sticks, leaves, dirt
- Toy animals or figures to represent living organisms in the habitat (optional)
- Blank paper or poster board

HANDS-ON INVESTIGATION

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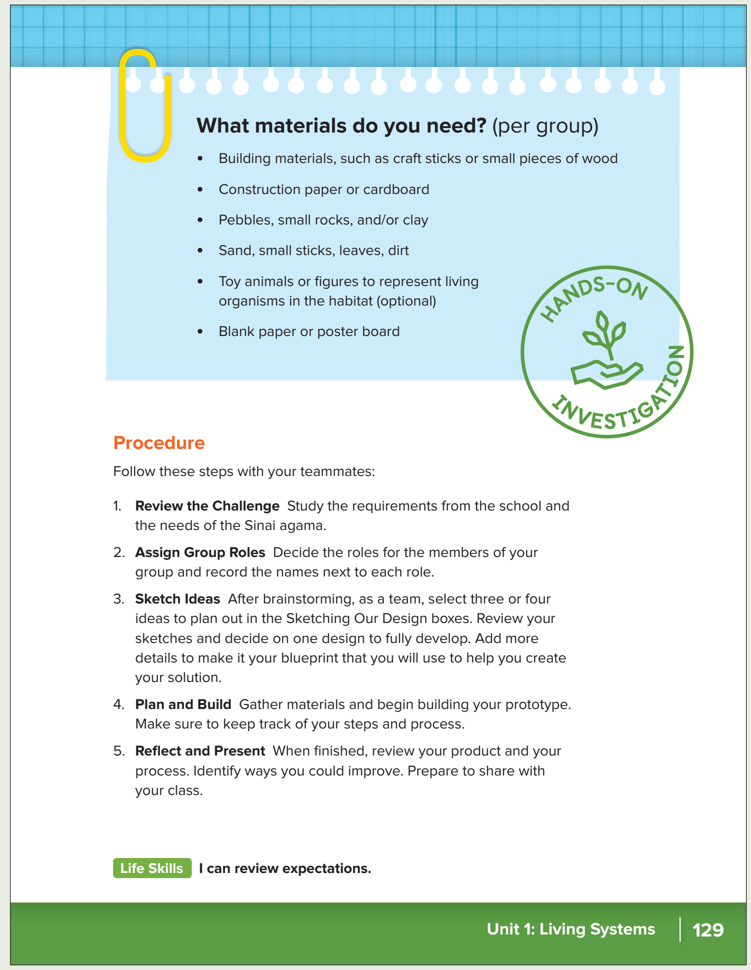

What materials do you need? (per group)

- Building materials, such as craft sticks or small pieces of wood
- Construction paper or cardboard
- Pebbles, small rocks, and/or clay
- Sand, small sticks, leaves, dirt
- Toy animals or figures to represent living organisms in the habitat (optional)
- Blank paper or poster board

HANDS-ON INVESTIGATION

Procedure

Follow these steps with your teammates:

1. **Review the Challenge** Study the requirements from the school and the needs of the Sinai agama.
2. **Assign Group Roles** Decide the roles for the members of your group and record the names next to each role.
3. **Sketch Ideas** After brainstorming, as a team, select three or four ideas to plan out in the Sketching Our Design boxes. Review your sketches and decide on one design to fully develop. Add more details to make it your blueprint that you will use to help you create your solution.
4. **Plan and Build** Gather materials and begin building your prototype. Make sure to keep track of your steps and process.
5. **Reflect and Present** When finished, review your product and your process. Identify ways you could improve. Prepare to share with your class.

Life Skills **I can review expectations.**

Unit 1: Living Systems | 129

Interdisciplinary Project, *continued*

2. **Assign Group Roles** Go over each group role as a class. Then support groups as needed to discuss and choose roles for each member of the group. Have every student in a group record names in the Group Roles table so that groups can review the list at the beginning of each lesson. Remind students that every role is essential to the group's success.

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Interdisciplinary Project

Group Roles

Roles	Student name
Team Captain Provide encouragement and support; help other team members with their roles if needed; keep track of timeline	
Materials Manager Gather and organize materials; request additional materials if needed	
Chief Engineer Coordinate building the model; suggest when a test may be needed; make sure the team is building safely	
Team Reporter Record all steps of the process; share the process the team went through to complete the challenge	

Design Requirements

- ☐ Your solution must include a diagram and small prototype of your sidewalk design, as well as a presentation sharing both your prototype (product) and how you worked together as a team (process).
- ☐ Your solution can only use materials the school has available: planks of wood, concrete, gravel, and natural materials found near the path, such as different size rocks, sand, dirt, sticks, and fallen leaves.

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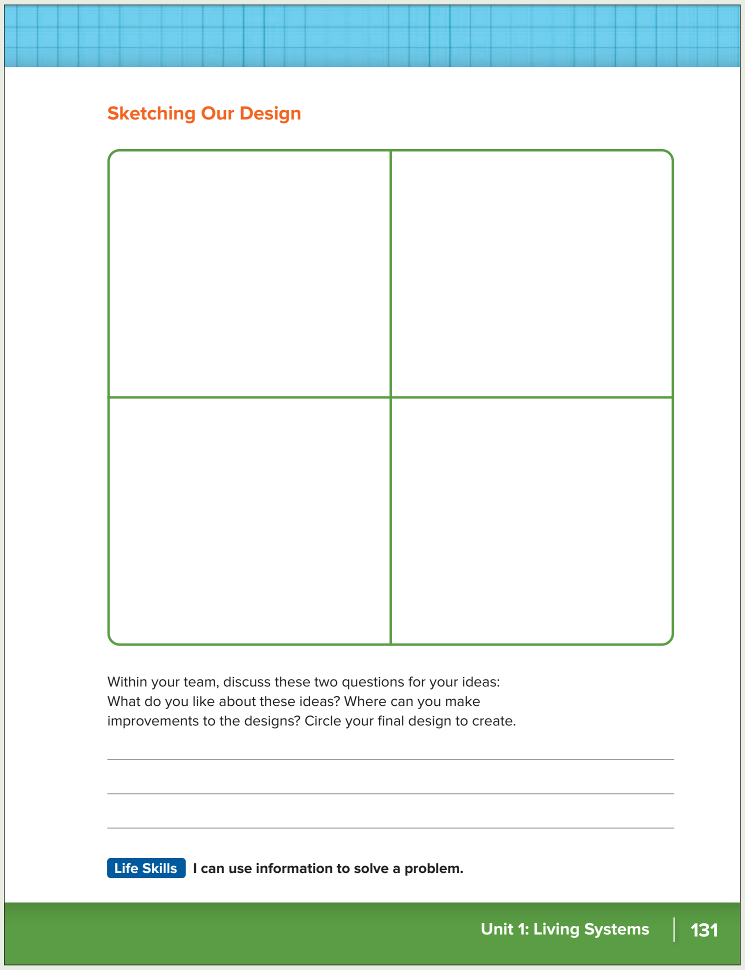

Sketching Our Design

Within your team, discuss these two questions for your ideas: What do you like about these ideas? Where can you make improvements to the designs? Circle your final design to create.

Life Skills I can use information to solve a problem.

Unit 1: Living Systems | 131

Interdisciplinary Project, *continued*

3. **Sketch Ideas** Students first brainstorm ideas for solutions in their groups. After some brainstorming, groups each select four ideas to plan out in the Sketching Our Design boxes. Each group member sketches at least one idea. Remind students that design sketches should include labels or notes and do not need to be artistic. Groups then review each member's sketches and decide on one design to fully develop. The questions provided beneath the sketching area support this discussion. To further support student groups in choosing a final design,

ASK
- *Does the design meet the requirements?*
- *Can students build a prototype of the design?*

Consider the following discussion protocol for classes that are new to this type of collaboration:

- Two students in the group have a discussion about which design they would select based on the requirements and questions above.
- While the pair is discussing, the other two members of the group are actively listening.
- The listening pair can also jot down any ideas that they want to remember. After several minutes, have the two pairs switch roles.

Interdisciplinary Project, *continued*

4. **Plan and Build** The Plan and Build section of this project includes multiple steps.
    - Provide groups with a separate piece of paper or small poster board. Students begin by drawing a full diagram of the chosen solution with more details than the previous sketches. This diagram will be used as a blueprint, so remind students to label parts and materials to be used on the diagram.
    - Review and display the materials that are available to construct prototypes. Adjust the items listed as needed based on the materials available. Make sure that materials available represent those that would be used if the designs were built to scale. After reviewing and discussing materials in groups, the Materials Manager gathers materials and groups begin building a prototype. Remind students to keep track of the steps taken and building process.

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Interdisciplinary Project

Plan and Build

STEP 1 Now that you have selected one design idea, create a separate diagram with additional details that you will share during your presentation. This detailed diagram is the blueprint for your prototype. Identify any materials you will use on the detailed diagram.

STEP 2 Gather the materials you identified in your blueprint. You may need to make adjustments to these materials as you are building. Keep track of what you actually use.

STEP 3 Begin building your prototype. As you build, you may run into problems or challenges. Focus on one problem at a time and use your group's creativity and collaboration skills to find solutions. Engineers use notebooks and documentation to troubleshoot when things go wrong so that they can look for places to make improvements.

STEP 4 Once your prototype is complete, work with your team to create a presentation to share both your product and your process. Be sure to explain the parts of your prototype that help all of the living organisms in the habitat. Also make sure to prepare to share how your team worked together, if you encountered any problems, and how you worked to make improvements.

Presentation Notes

Life Skills **I can decide on a solution to use.**

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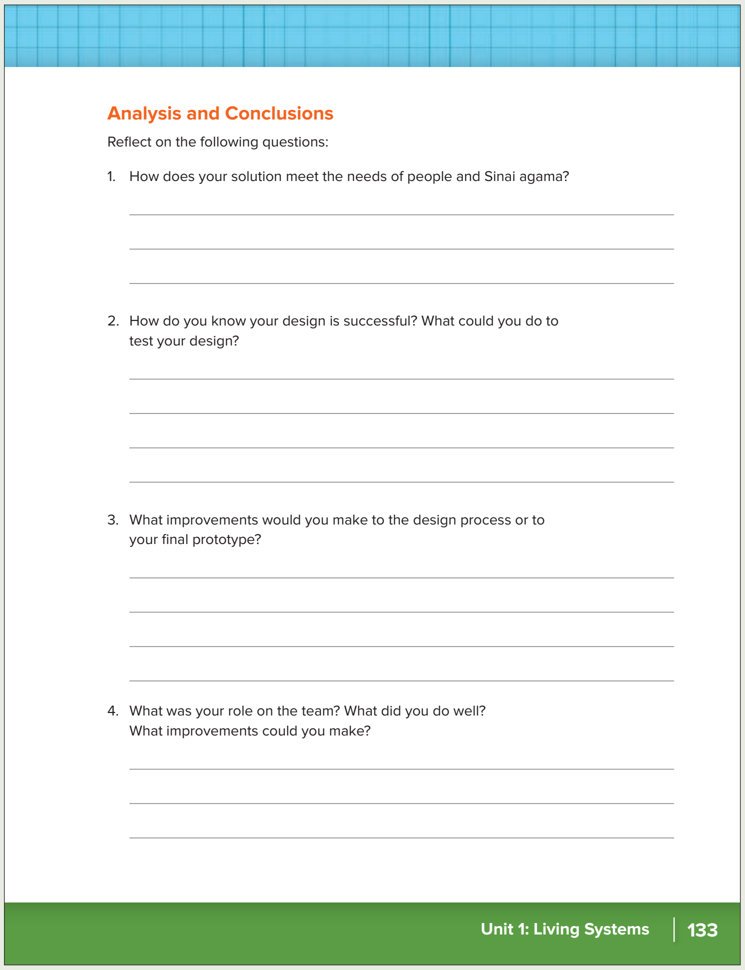

Analysis and Conclusions

Reflect on the following questions:

1. How does your solution meet the needs of people and Sinai agama?
2. How do you know your design is successful? What could you do to test your design?
3. What improvements would you make to the design process or to your final prototype?
4. What was your role on the team? What did you do well? What improvements could you make?

Unit 1: Living Systems | 133

Interdisciplinary Project, *continued*

5. **Reflect and Present** When finished building, instruct groups to review the prototype and group process.

ASK
- *How could you improve your design?*
- *How could your group improve how you worked together?*

After a brief initial reflection, groups discuss the Analysis and Conclusions questions. Each group member records answers in their own words.

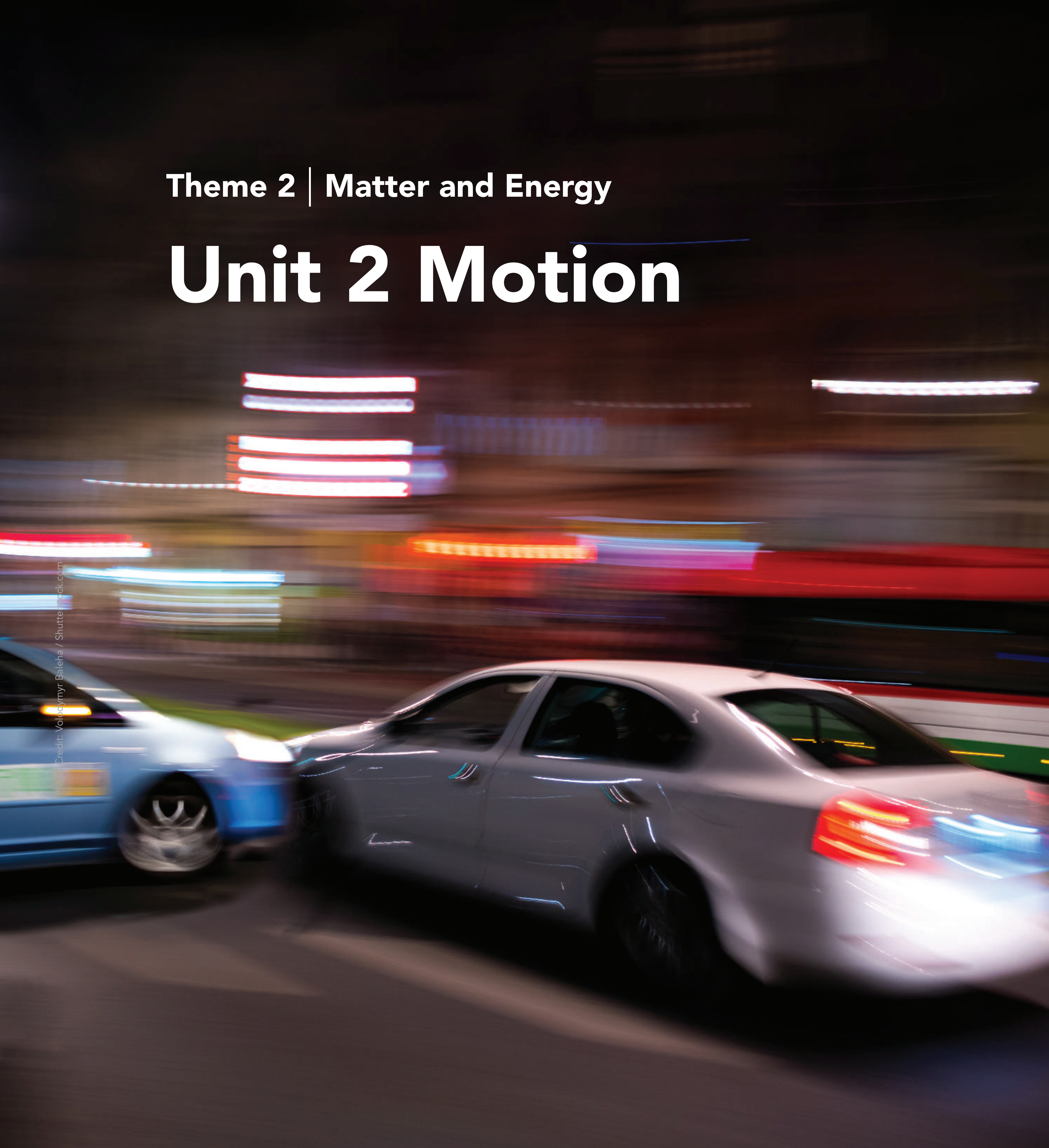
As time allows, have groups present their prototypes and reflections with the whole class or with one other group.

UNIT
2 | Motion

Photo Credit: Volodymyr Baleha / Shutterstock.com

Theme 2 | Matter and Energy

Unit 2 Motion



Credit: Volodymyr Baleha / Shutterstock.com

Learning Indicators

Throughout this unit, students will work toward the following learning indicators:

Primary 4 • CONCEPT	2.1	2.2	2.3	2.4
SCIENCE				
A. Skills and Processes				
1. Demonstrate thinking and acting inherent in the practice of science.				
a. Identify scientific and non-scientific questions.	•	•	•	•
b. Plan and carry out simple investigations to collaboratively produce data that answers a question.	•	•	•	•
c. Represent data in tables and graphs, compare the styles of representation.	•	•	•	•
d. Construct an argument with evidence and data.	•	•	•	•
e. Develop and/or use models to explain natural phenomena.	•	•	•	•
f. Use multiple texts to answer questions or explain phenomena.	•	•	•	•
g. Communicate scientific information orally and in written formats.	•	•	•	•

	2.1	2.2	2.3	2.4
D. Physical Science				
1. Use scientific skills and processes to explain the chemical and physical interactions of the environment, Earth, and the universe that occur over time.				
a. Use evidence to construct an explanation relating the speed of an object to the energy of that object. 1) Explain the basic connection between energy and movement.	•	•	•	•
b. Ask questions and predict outcomes about the changes in energy that occur when objects collide.	•			•
c. Summarize observations of how energy can be transferred from place to place by sound, light, heat, and/or electric currents. 1) Identify various forms of energy. 2) Describe everyday examples of energy changing from one form to another. 3) Explain how some everyday devices transform energy. 4) Identify the energy transformations that occur when energy is used to run a device in the home or school.	•	•		•
d. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. *[Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and a passive solar heater that converts light into heat.]*		•		•
F. Engineering Design and Process				
a. With support, explain the characteristics and scope of technology.		•		•
b. With support, explain the role of society in the development and use of technology.				•
c. Define a simple design problem that can be solved through the development of an object, tool, process, or system.		•		•
d. Apply the design process with support, using tools and materials to plan and/or build a device that solves a specific problem.		•	•	•
e. Analyze data from tests of an object or tool to determine whether it works as intended.			•	•

Unit Outline

Anchor Phenomenon: Get Started

The Science of Car Crashes
Students will learn about what happens in a crash. They will explore what happens to energy when objects collide and why car crashes cause so much damage.

Unit Project Preview

Vehicle Safety
Students will consider how safety features work to protect passengers in a vehicle.

Concepts

2.1 Starting and Stopping
Students will learn that objects move when an unbalanced force is applied and that energy changes take place when a force is applied to an object.

2.2 Energy and Motion
Students will learn that work occurs when a force moves an object and that energy, which is needed to work, comes in different forms that can be used, via energy changes, to move objects.

2.3 Speed
Students will learn that speed is the distance moved by an object over a specified period of time and understand the relationship between the speed of an object and its kinetic energy.

2.4 Energy and Collisions
Students will learn that energy changes occur when objects collide, the amount of energy that colliding objects have depends on their masses and speeds, and the collision energy is conserved.

Unit Project

Vehicle Safety
In this project, students research and redesign a safety feature of a passenger vehicle.

Unit Storyline

Even the youngest learners are fascinated by force and motion, primarily because it is so easy to observe. Children naturally experiment with pushing and pulling objects by rolling balls down ramps and watching as objects collide or stop moving. In this unit, the unfortunately all-too-common experience of a car crash is used to illustrate the science behind motion, force, energy, and collisions. By focusing on vehicular safety in the unit project, students will hopefully begin to connect the ideas of force and motion with the passenger experience while riding in a car or other moving vehicle.

The first concept focuses on starting and stopping motion. Students investigate using simple, household objects to learn more about how balanced and unbalanced forces cause starting or stopping. Next, students learn about the relationship between energy, work, and force, and look more deeply at different types of energy and energy changes. The relationship between speed and motion is the focus of the third concept, where students are first introduced to the idea of distance over time. Finally, students examine what happens when two objects moving with a lot of speed, such as a bat and a ball, or two cars, collide with each other. Students make predictions about the energy transformations that occur during a collision and connect energy transformations to the forces that are exerted on the colliding objects.

While the physics behind vehicular safety features involves concepts that students will not learn until much later in science, students will synthesize their foundational ideas about force, energy transformation, speed, and collisions to think critically about how to make improvements.

Unit 2 Introduction: Get Started

What I Already Know

Quick Code: egst4081

The second unit in Primary 4 Science is focused on energy and motion. Begin the unit by asking students to share what they have previously studied about forces, motion, and energy. Students might recall the differences between push/pull forces, experimenting with objects sliding or rolling down ramps, and simple ideas about energy in the form of light or heat.

Students are asked to examine an image of a man in a wheelchair. Before students consider the questions that accompany the image, ask them to share what they know about wheelchairs and wheelchair ramps. If students do not offer ideas about wheelchairs, provide additional examples such as a baby carriage or a wagon. Encourage students to think about and discuss any initial ideas about what kinds of forces might be needed to move the wheelchair, carriage, or wagon. At this stage, fully formed or scientifically accurate answers are less important than motivating student interest and inquiry.

Shift the class discussion from the familiar ideas of force and motion in the What I Already Know activity to watch the video, study the image, and read the provided text for The Science of Car Crashes. Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Get Started

What I Already Know

Quick Code: egs4081

This unit is all about energy and motion. **Think** about objects that move. Do they move in a specific way? **Look** at the image of the man in the wheelchair on the ramp. How do you think the man and his wheelchair will move? Will he need additional force to move? Will the ramp help his movement?

Wheelchair at the Top of a Ramp

Answers will vary. The wheels on the chair will help the man move down the ramp because they will roll downhill. If the ramp is not steep enough, he might need a push to get started. If he was trying to go up the ramp, he would have to use more force.

Talk Together Think about the energy required to move objects like a car or a train. Share your ideas about where the energy for motion of vehicles comes from.

During this unit, you will learn a lot more about how energy and motion are related. You will explore starting and stopping and how energy changes when forces are applied to objects. You will learn the relationship between energy and work, which happens when forces move objects. You will investigate speed by looking closely at the distance objects travel when moving and how long they travel. Finally, you will investigate what happens when objects collide, or crash together.

Photo Credit: (a) Volodymyr Baleha / Shutterstock.com, (b) UfaBizPhoto / Shutterstock.com

Unit 2: Motion | 135

Anchor Phenomenon: The Science of Car Crashes

The focus of this unit, energy and motion, is put into context with the idea of a car crash. While no one wants to be in a car accident, students likely have seen a collision involving moving vehicles. Encourage students to share experiences, including how cars or other passenger vehicles might be damaged in a crash and

how the design of cars actually helps to protect the riders or the items inside. Most passenger vehicles, including automobiles, buses, and trains, are equipped with specific safety features to protect both the structure of the vehicle itself and the passengers and contents. Remind students that safety is one of the most important features that influence the design of vehicles, and that manufacturers are constantly working toward improvement.

The Science of Car Crashes

As students develop an understanding of the connections between motion, energy, work, and speed, return to the experience students have with collisions and safety.

Guiding Questions

- What happens to energy when objects collide?
- Why do car crashes cause so much damage?

Unit Project Preview

Vehicle Safety

Quick Code: egst4082

Introduce the idea of a unit project to students. Students should be familiar with project-based assessments from previous study in lower grades. The unit project asks students to combine their learning about energy, motion, and collision to research and redesign a safety feature of a passenger vehicle. Encourage students to think of additional questions they have about vehicle safety before starting the first concept. You may wish to post these questions in the classroom as an ongoing reminder throughout the unit.

Question

How can you improve a device to keep passengers safe in a car crash?

Photo Credit: (a) Kwangmoozaa / Shutterstock.com, (b) Tharin Sinlapachai / Shutterstock.com

CONCEPT

2.1 Starting and Stopping

Concept Objectives

By the end of the lesson, students should be able to:

- Construct explanations of how the forces acting on objects cause them to change their motion.
- Analyze and interpret data to describe how different amounts of force cause an object to move different distances.
- Construct explanations based on evidence and logical reasoning that the speed of an object is related to the work done on that object and the energy of the object.
- Develop a model of the cause and effect relationship between force applied to an object and the motion of an object.

Quick Code: egst4083

Key Vocabulary

new: energy, force, friction, gravity, motion, work

Quick Code: egst4084

Key Vocabulary Strategies

Teach the Word

- Group students. Assign each group member a word. That student is in charge of learning the word and teaching it to the rest of the students in the group, who should take notes. Provide students with some basic reference materials (such as videos or text definitions) to help them prepare their explanation.
- Call on individual students to share their group member's explanation and whether they think they understood the word's meaning.

Guess the Word

- Select the vocabulary words to introduce, divide the class into small teams, and assign a word to each team without revealing it to the rest of the class. Also provide the teams with a list of interview questions about their word and have them prepare the answers. Then, be the interviewer and ask the questions to the corresponding team. For example, you could ask the group assigned the word *gravity* questions such as: *Is it a noun, adjective, or verb? Does it refer to matter, energy, or some phenomenon? Where could we find it? How can you observe it?* and so on.
- After a team has answered all the questions, have the rest of the class guess the assigned word.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Get Started		Get Started	15 min
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	20 min
	Lesson 2	Activity 3	15 min
		Activity 4	10 min
Learn		Activity 5	20 min
	Lesson 3	Activity 6	15 min
		Activity 8	20 min
		Activity 9	10 min
	Lesson 4	Activity 10	45 min
		Activity 11	10 min
Share	Lesson 5	Activity 12	20 min
		Activity 13	15 min

Content Background

When children play, they are usually unaware that they are participating in an exploration of many basic principles of physics, such as using the forces of push and pull. However, children understand more than they can explain in scientific terms because of the innate tendency that children have to experiment. The core tenants of physical science are simple ideas. Students can draw on their concrete experiences as context for understanding the more abstract scientific applications of concepts such as force, work, and energy. Helping students bridge the gap between understanding daily experiences and expressing these phenomena using academic language is an important starting foundation for the study of motion.

Balanced and Unbalanced Forces

A force is a push or pull. When a force is applied to an object, several things may happen. If the new force is opposed by an equivalent force acting in the opposite direction, the two forces are considered balanced, and the object will not move. For example, if a person pushes a piece of furniture against a wall. The force of the wall pushing back on the object balances the force that the person exerts on the furniture, and the furniture does not move. Likewise, when a book rests on a desk, the downward force of gravity is balanced by an equal, but opposite, force of the desk pushing up against the book.

In some situations, though, one force is greater than the other. When a person pushes open a door, the force applied to the door is greater than the force of the weight of the door pushing back. In cases such as this, the forces are considered unbalanced, and the object will move. This resulting change in position over a period of time is motion. When this happens, work is done on the object. For scientists, work is done when a force moves an object over a distance. When an object is set in motion, stored energy, also known as potential energy, is transformed into the energy of motion, kinetic energy, and work is done.

Natural Forces

In addition to forces applied by humans or other living things, there are several important natural forces that students will be asked to consider in this first concept. These include gravity, which is the attractive force between two massive bodies, and friction, which is a force that opposes the motion of an object across a surface or through a medium.

Content Background, *continued*

Frictional Forces

Frictional forces exert a force in the direction opposite of an object's motion, causing the object to slow or come to a stop. However, frictional forces also help put objects in motion. When a person walks, his or her foot pushes back against the ground, and the frictional force between the ground and foot allows the force of the leg to push the person forward. (Note that when there is not enough friction between the foot and the ground, such as when the ground is icy or wet, a person will slip.)

Hands-On Investigations Preparation

Learn

Location	Instructional Focus	Materials to Prepare (per group)
Activity 10: Rolling Cars	In this activity, students collect and analyze data about model cars' speeds to construct an explanation about the relationship between speed and energy in different scenarios.	• Toy trucks, cars • Measuring tape

Lesson 1

Activity 1
Can You Explain?

10 min

How do forces act on a starting and stopping object?

Purpose

This activity draws on students' prior knowledge and personal experiences by asking them to consider how forces act on a starting and stopping object.

Instructional Focus

In this activity, students use prior experience to construct an explanation of what forces are necessary to start a car moving.

Life Skills **Endurance**

Strategy

Students may have some initial ideas about how to answer the question using personal experiences and what they already know. (See sample student response in the student edition.)

For students struggling to answer, prompt their thinking with the following questions:

- How many of you rode in a car or bus sometime this week?
- What forces were necessary to get the car or bus in motion?

By the end of the concept, students should be able to construct a scientific explanation, which includes evidence from the concept activities.

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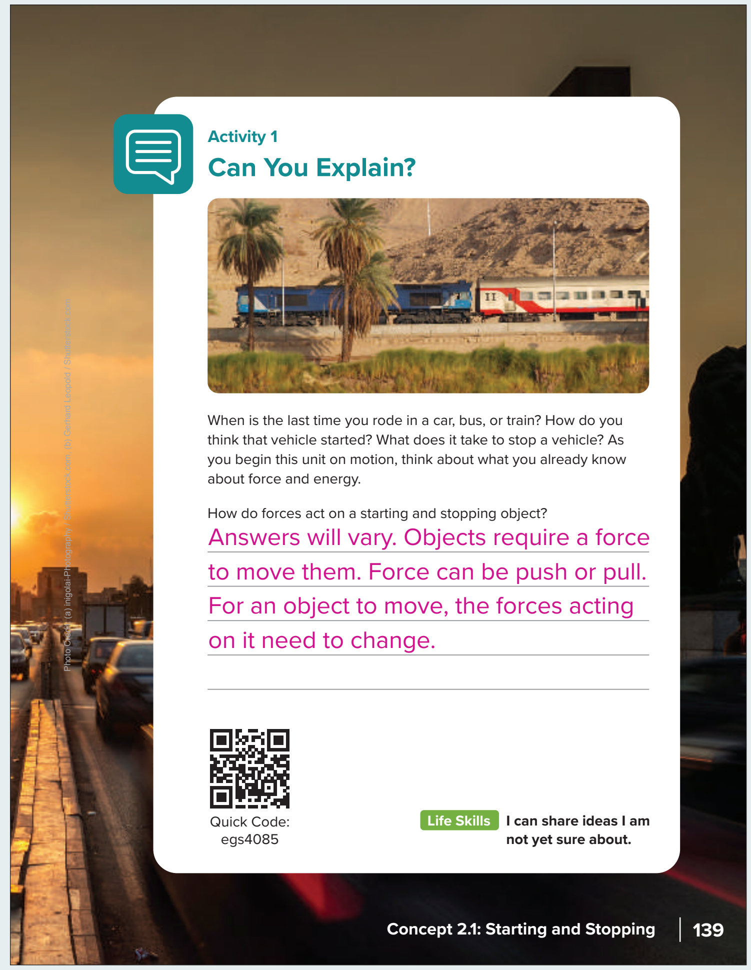

Activity 1

Can You Explain?

When is the last time you rode in a car, bus, or train? How do you think that vehicle started? What does it take to stop a vehicle? As you begin this unit on motion, think about what you already know about force and energy.

How do forces act on a starting and stopping object?

Answers will vary. Objects require a force to move them. Force can be push or pull. For an object to move, the forces acting on it need to change.

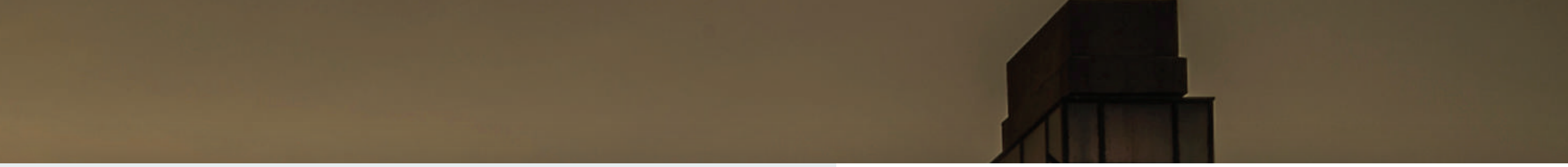
Quick Code: egs4085

Life Skills I can share ideas I am not yet sure about.

Concept 2.1: Starting and Stopping | 139

DIGITAL

Quick Code: egst4085



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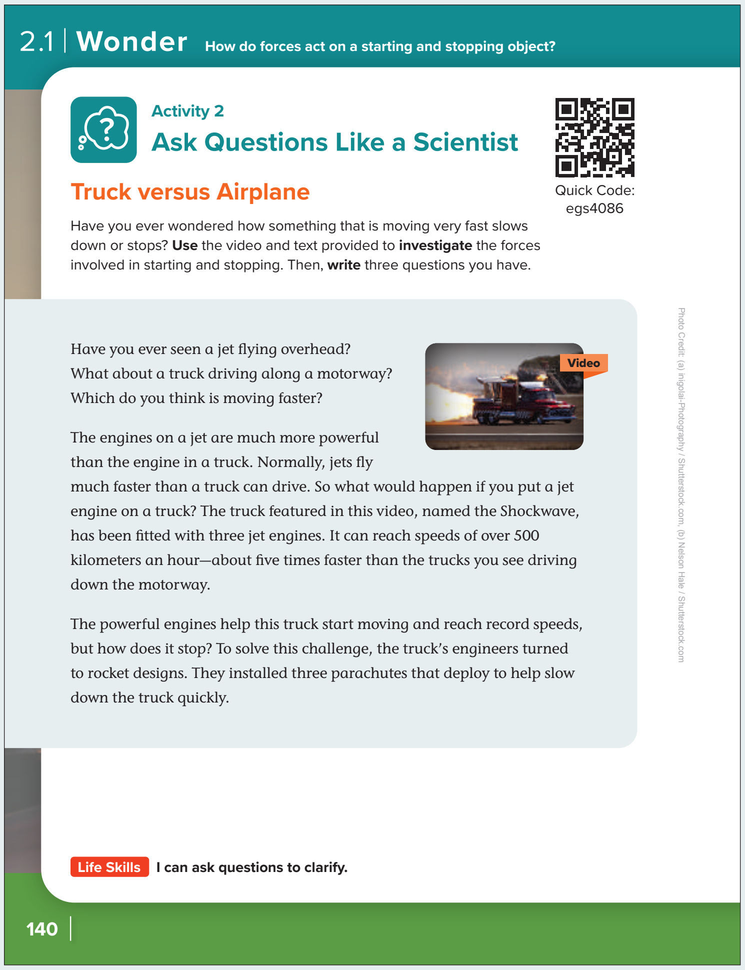

2.1 | **Wonder** How do forces act on a starting and stopping object?

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4086

Truck versus Airplane

Have you ever wondered how something that is moving very fast slows down or stops? **Use** the video and text provided to **investigate** the forces involved in starting and stopping. Then, **write** three questions you have.

Have you ever seen a jet flying overhead? What about a truck driving along a motorway? Which do you think is moving faster?

Video

The engines on a jet are much more powerful than the engine in a truck. Normally, jets fly much faster than a truck can drive. So what would happen if you put a jet engine on a truck? The truck featured in this video, named the Shockwave, has been fitted with three jet engines. It can reach speeds of over 500 kilometers an hour—about five times faster than the trucks you see driving down the motorway.

The powerful engines help this truck start moving and reach record speeds, but how does it stop? To solve this challenge, the truck's engineers turned to rocket designs. They installed three parachutes that deploy to help slow down the truck quickly.

Photo Credit: (a) inigolai-Photography / Shutterstock.com, (b) Nelson Hale / Shutterstock.com

Life Skills I can ask questions to clarify.

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Photo Credit: Nelson Hale / Shutterstock.com

DIGITAL

Activity 2

Ask Questions Like a Scientist

Truck versus Airplane

Quick Code:
egst4086

Lesson 1, *continued*

Investigative Phenomenon

Activity 2
Ask Questions Like a Scientist

20 min

Truck versus Airplane

Purpose

The Investigative Phenomenon presents an engaging scenario—sometimes familiar and sometimes unfamiliar—to spark student curiosity about the world around them. This activity asks students to consider the role of force in stopping a fast-moving vehicle.

Instructional Focus

In this activity, students will watch a video and read a text about a truck racing an airplane and develop questions about the relationship between force and movement or speed.

Life Skills **Negotiation**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

After considering the familiar examples of trains, buses, and cars, students are now introduced to an extreme example of movement: a truck with jet engines. Ask students to share what they already know about the differences between jets and trucks so that they can consider this unique combination. Instruct students to read the text independently or in pairs, and then watch the video.

Lesson 1, *continued*

- Lead a class discussion and ask students to verbally define and agree upon the meaning of words such as *energy*, *force*, *movement*, and others they may use. Record agreed upon definitions in a place where students can read and reference the terms.
- Then, have students generate their own questions from the video or text related to forces and motion. Encourage students to focus their questions around: What makes the truck and airplane move? How do they start? How do they stop?

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- Would you organize this differently next year? If so, what would you change?
- Were students able to recall key information on force, friction, gravity, speed, and motion?

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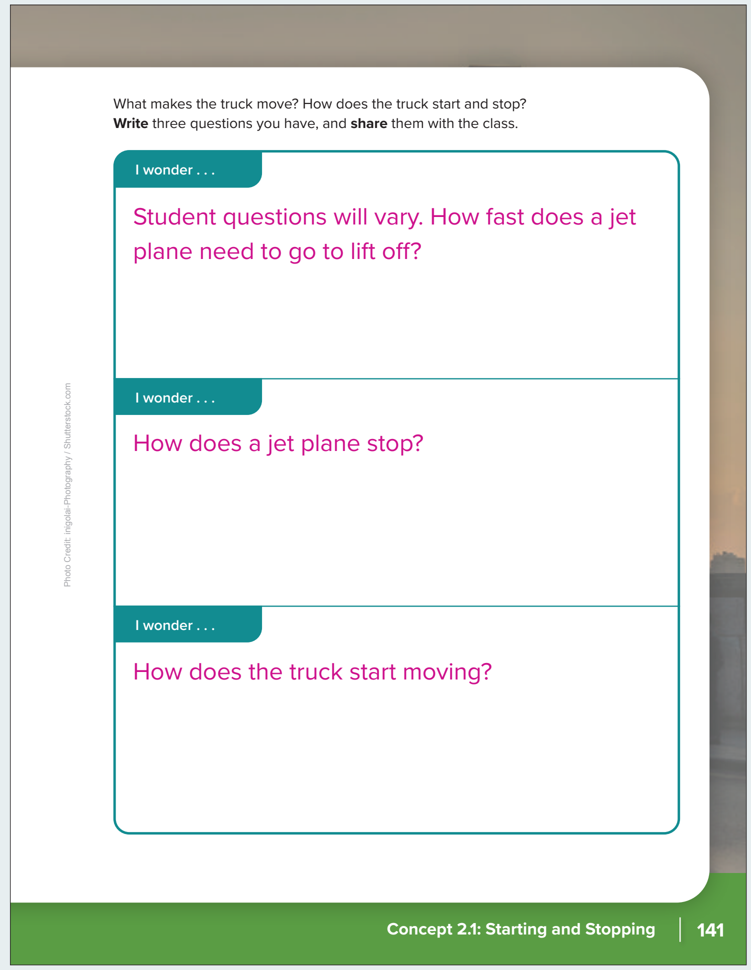


What makes the truck move? How does the truck start and stop?
Write three questions you have, and **share** them with the class.

I wonder . . .

Student questions will vary. How fast does a jet plane need to go to lift off?

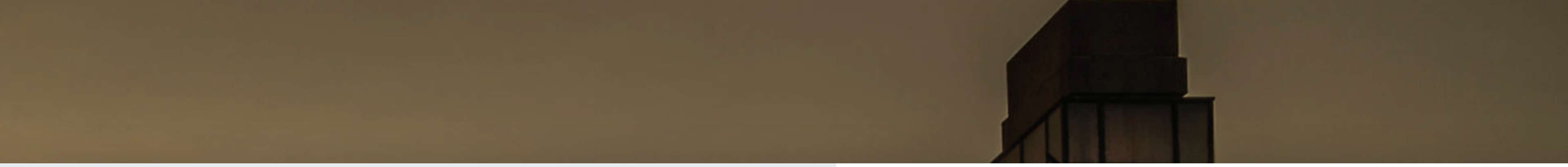
I wonder . . .

How does a jet plane stop?

I wonder . . .

How does the truck start moving?

Concept 2.1: Starting and Stopping | 141



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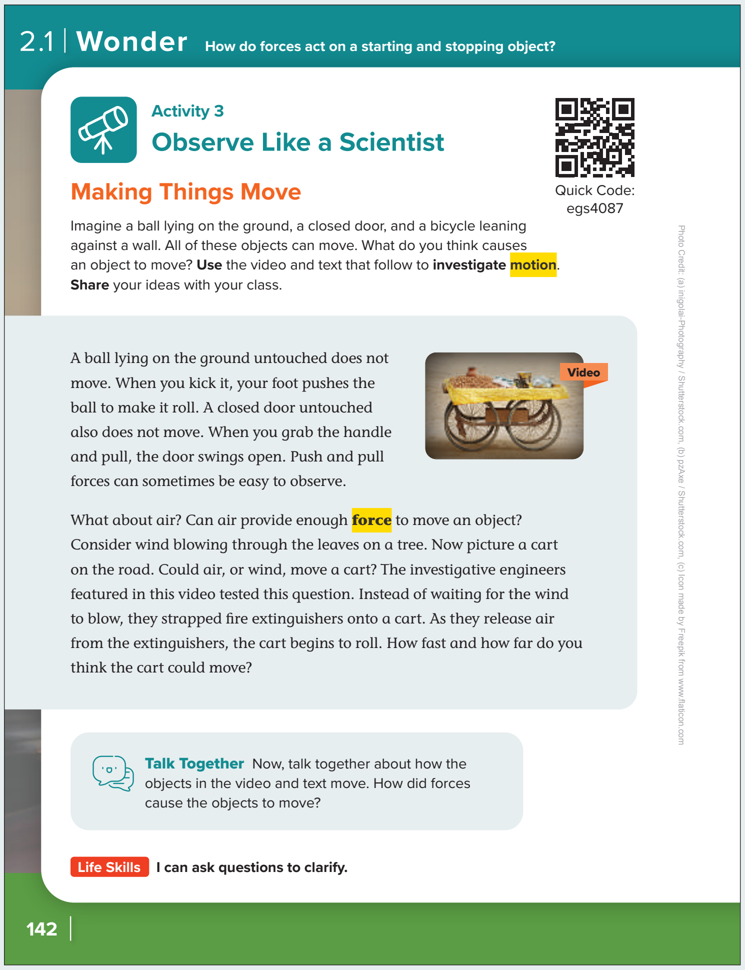

2.1 | **Wonder** How do forces act on a starting and stopping object?

Activity 3

Observe Like a Scientist

Quick Code: egs4087

Making Things Move

Imagine a ball lying on the ground, a closed door, and a bicycle leaning against a wall. All of these objects can move. What do you think causes an object to move? **Use** the video and text that follow to **investigate** **motion**. **Share** your ideas with your class.

A ball lying on the ground untouched does not move. When you kick it, your foot pushes the ball to make it roll. A closed door untouched also does not move. When you grab the handle and pull, the door swings open. Push and pull forces can sometimes be easy to observe.

Video

What about air? Can air provide enough **force** to move an object? Consider wind blowing through the leaves on a tree. Now picture a cart on the road. Could air, or wind, move a cart? The investigative engineers featured in this video tested this question. Instead of waiting for the wind to blow, they strapped fire extinguishers onto a cart. As they release air from the extinguishers, the cart begins to roll. How fast and how far do you think the cart could move?

Talk Together Now, talk together about how the objects in the video and text move. How did forces cause the objects to move?

Life Skills I can ask questions to clarify.

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Photo Credit: pzAxe / Shutterstock.com

DIGITAL

Quick Code:
egst4087

Lesson 2

Activity 3
Observe Like a Scientist

15 min

Making Things Move

Purpose

This activity allows students to discuss the questions generated in the previous activity and further consider what causes motion.

Instructional Focus

In this activity, students explore the cause-and-effect relationship between energy and motion and construct an explanation about how energy can be transferred between objects.

Life Skills **Negotiation**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the video, text has been provided to support learning.

Encourage students to consider what they already know about motion and its causes as they watch the video and read the companion text. Ask students to jot down questions to share in a whole-class discussion as they watch and read.

Facilitate a discussion where students use evidence from the video and text to explain how force causes motion. Start the discussion by asking the class to explain why changing the number of fire extinguishers changes the speed of the cart. During the discussion, encourage students to ask each other questions such as: How do you know? Do you have additional evidence?

Lesson 2, *continued*

Activate Prior Knowledge

Activity 4
Observe Like a Scientist

10 min

What Do You Already Know About Starting and Stopping?

Purpose

This activity is a formative assessment to find out what students already know about the role of force in making objects move.

Instructional Focus

In this activity, students consider the various factors that characterize an object's motion based on what they already know about motion and change.

How Do Objects Move?

Strategy

This item provides a formative assessment of students' ability to distinguish the two ways forces are applied to objects.

Balanced and Unbalanced

Strategy

The item assesses students' existing knowledge of balanced and unbalanced forces. Students analyze visual data to evaluate two opposite energies applied to a rope and predict the direction it will move.

Students may believe that an object always moves in the direction of a force applied to the object. In fact, there are often several forces acting on an object when it is moving (gravity, friction, air resistance). The direction of motion is determined by the sum of all the forces, or the net force, acting on the object.

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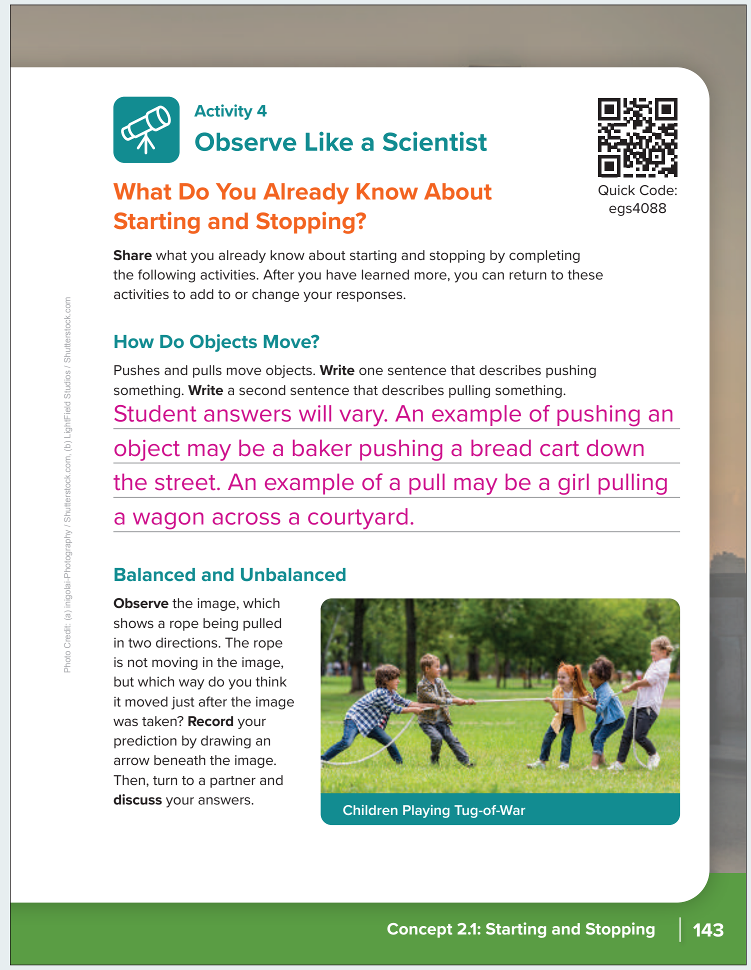

Activity 4
Observe Like a Scientist

Quick Code: egs4088

What Do You Already Know About Starting and Stopping?

Share what you already know about starting and stopping by completing the following activities. After you have learned more, you can return to these activities to add to or change your responses.

How Do Objects Move?

Pushes and pulls move objects. **Write** one sentence that describes pushing something. **Write** a second sentence that describes pulling something.

Student answers will vary. An example of pushing an object may be a baker pushing a bread cart down the street. An example of a pull may be a girl pulling a wagon across a courtyard.

Balanced and Unbalanced

Observe the image, which shows a rope being pulled in two directions. The rope is not moving in the image, but which way do you think it moved just after the image was taken? **Record** your prediction by drawing an arrow beneath the image. Then, turn to a partner and **discuss** your answers.

Children Playing Tug-of-War

Concept 2.1: Starting and Stopping | 143

DIGITAL

Activity 4
Observe Like a Scientist
What Do You Already Know About Starting and Stopping?

Quick Code:
egst4088

Photo Credit: LightField Studios / Shutterstock.com

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How Do We Know an Object Is Moving?

Activity 5

Analyze Like a Scientist

Quick Code: egs4089

Objects in Motion

What is motion? What causes objects to start and stop moving? **Look** for answers to these questions as you **read** the text about objects in motion. Then, **answer** the questions that follow.

Objects in Motion

Think of a time when you played catch with a friend. The ball left your hands, travelled through the air, and then was caught by your friend. The ball landed in a different place from where it started, because it moved.

An object is in motion if it is moving from one place to another. When you look at an object, you can describe its position compared to other things around it. Imagine that you are standing next to a tree when you are playing catch. The starting position of the ball is close to the tree. When the ball travels through the air, it is in motion. It stops moving when your friend catches it. The ball's position changes, relative to the tree. Motion is any change in position relative to a fixed starting point.

Life Skills I can analyze a situation.

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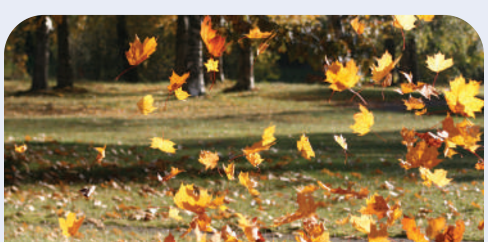

Activity 5

Analyze Like a Scientist

Objects in Motion

Quick Code: egst4089

Lesson 2, *continued*

How Do We Know an Object Is Moving?

Activity 5

Analyze Like a Scientist

20 min

Objects in Motion

Purpose

This reading passage serves as an introduction to some of the key ideas that students will explore throughout the concept. In order to understand motion, students must be familiar with the factors that describe, define, and affect motion.

Instructional Focus

In this activity, students focus on the indicators that define an object's motion and the types of force that cause motion.

Life Skills **Decision-Making**

Lesson 2, *continued*

Strategy

Ask students to read the text to find evidence to explain what defines and causes motion.

- Before reading the text, toss a ball around the classroom. Lead a class discussion on how they know the object is in motion.
- Then, ask students to read the text. After the students have finished reading, revisit the discussion. Help students to use the correct vocabulary from the reading to explain their thinking.

ASK

- *What two things must occur for a ball to be in motion?*
  Sample Answer: A force must act on the ball to start motion and the position of the ball must change.
- *What are the two types of forces that can be used to put a ball into motion?*
  Sample Answer: The two types of forces that can put a ball into motion are a push or a pull.

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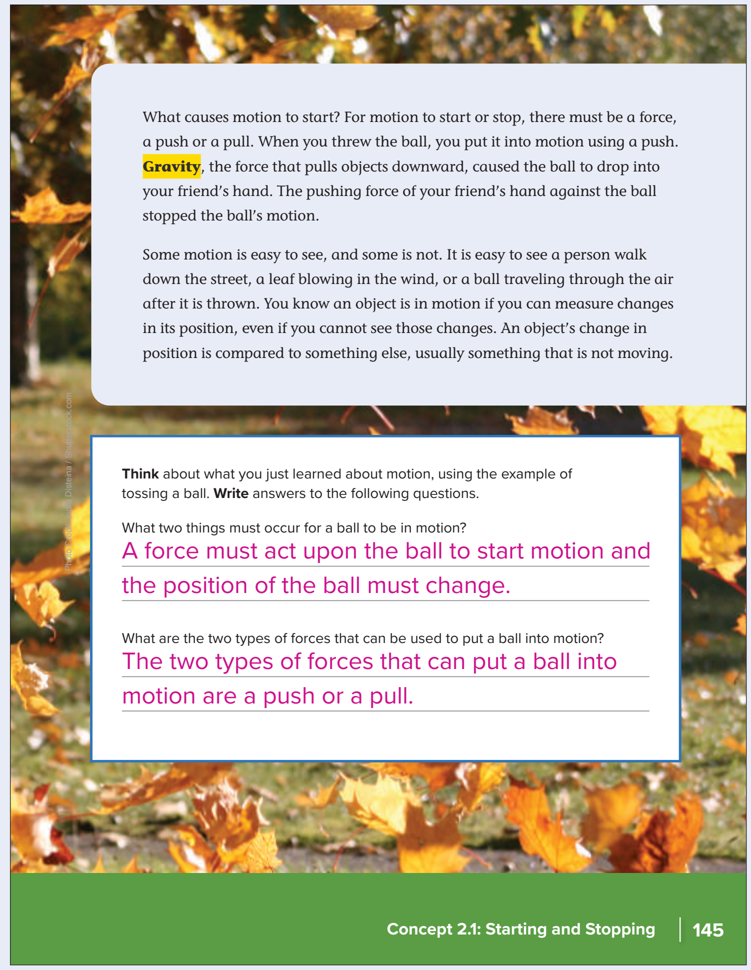


What causes motion to start? For motion to start or stop, there must be a force, a push or a pull. When you threw the ball, you put it into motion using a push. **Gravity**, the force that pulls objects downward, caused the ball to drop into your friend's hand. The pushing force of your friend's hand against the ball stopped the ball's motion.

Some motion is easy to see, and some is not. It is easy to see a person walk down the street, a leaf blowing in the wind, or a ball traveling through the air after it is thrown. You know an object is in motion if you can measure changes in its position, even if you cannot see those changes. An object's change in position is compared to something else, usually something that is not moving.

Think about what you just learned about motion, using the example of tossing a ball. **Write** answers to the following questions.

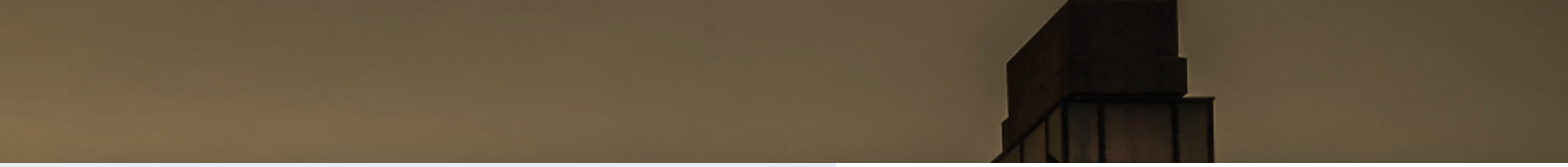
What two things must occur for a ball to be in motion?

A force must act upon the ball to start motion and the position of the ball must change.

What are the two types of forces that can be used to put a ball into motion?

The two types of forces that can put a ball into motion are a push or a pull.

Concept 2.1: Starting and Stopping | 145



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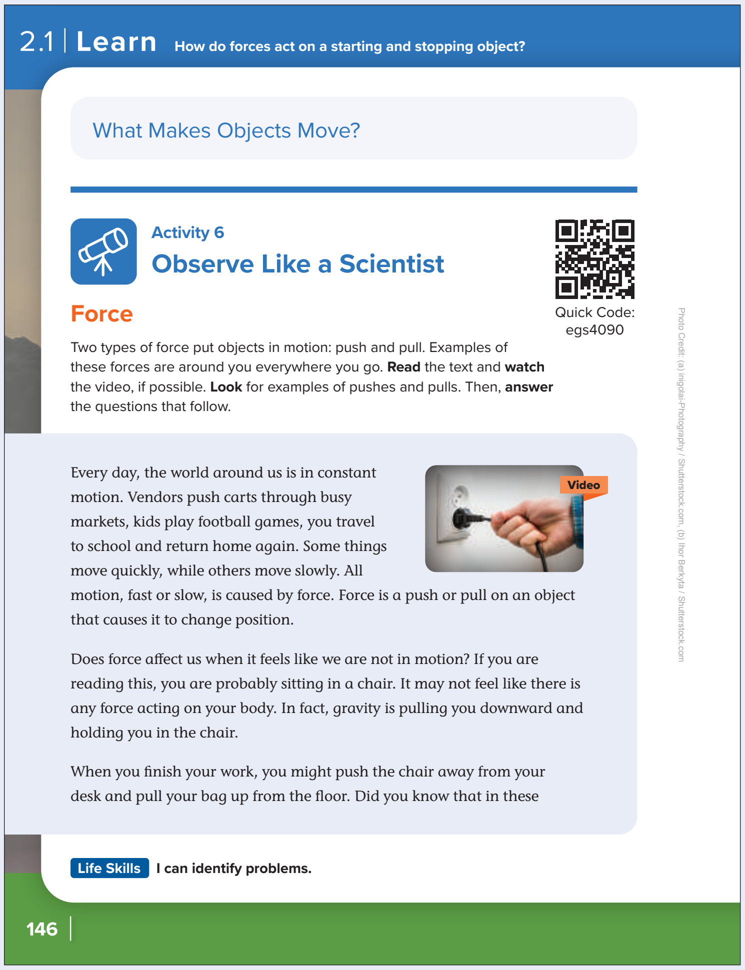
2.1 | Learn How do forces act on a starting and stopping object?

What Makes Objects Move?

Activity 6

Observe Like a Scientist

Quick Code: egs4090

Force

Two types of force put objects in motion: push and pull. Examples of these forces are around you everywhere you go. **Read** the text and **watch** the video, if possible. **Look** for examples of pushes and pulls. Then, **answer** the questions that follow.

Video

Every day, the world around us is in constant motion. Vendors push carts through busy markets, kids play football games, you travel to school and return home again. Some things move quickly, while others move slowly. All motion, fast or slow, is caused by force. Force is a push or pull on an object that causes it to change position.

Does force affect us when it feels like we are not in motion? If you are reading this, you are probably sitting in a chair. It may not feel like there is any force acting on your body. In fact, gravity is pulling you downward and holding you in the chair.

When you finish your work, you might push the chair away from your desk and pull your bag up from the floor. Did you know that in these

Life Skills I can identify problems.

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Photo Credit: Ihor Berkyta / Shutterstock.com

DIGITAL

Activity 6
Observe Like a Scientist
Force

Quick Code:
egst4090

Lesson 3

What Makes Objects Move?

Activity 6
Observe Like a Scientist

15 min

Force

Purpose
Students were introduced to the forces that start and stop motion in the text Objects in Motion. This activity establishes a real-world context for the somewhat abstract concept of force, so that students have a solid basis for understanding these ideas as lessons move into more complex topics, such as energy, speed, and collisions.

Instructional Focus
In this activity, students engage in a discussion about the cause-and-effect relationship between push and pull forces and motion in their daily lives.

Life Skills **Critical Thinking**

Strategy
Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before reading the text, ask students to think about what they have already learned about forces that start and stop motion.

ASK
- What types of force can start or stop motion?
  A push or a pull can start or stop motion.

Lesson 3, *continued*

ASK

- What are some examples of starting or stopping motion with a push?
  Student answers may include examples such as playing with toy cars, pushing a friend on a swing, or throwing a ball.
- What are some examples of starting or stopping motion with a pull?
  Student answers may include examples such as a toddler playing with a pull toy, pulling a door open, or pulling on a rope in tug-of-war.

Pair students with a partner to read the text. After students finish reading, show students the video. Ask students to consider whether life would be possible if the forces of push or pull did not exist.

ASK *How would your lives change or become more difficult? Would life even be possible?* *Student answers will vary. Most students will understand that we would be unable to move objects without these forces. However, students may not automatically consider that activities such as walking are a result of pushing and pulling.*

Encourage students to deepen their reasoning by asking questions such as, *What would happen if we could push things in one direction only? What happens if we push an object with twice the force that we pull it?*

Optional Digital Activity 7
Observe Like a Scientist

10 min

Tug-of-War

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code:
egst4429

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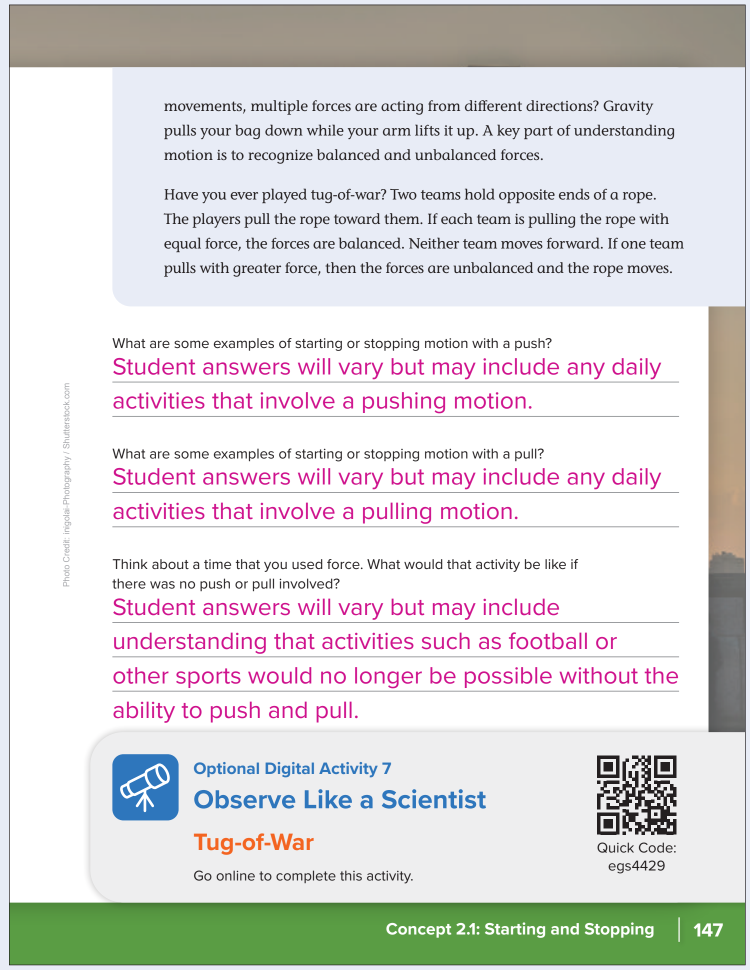


movements, multiple forces are acting from different directions? Gravity pulls your bag down while your arm lifts it up. A key part of understanding motion is to recognize balanced and unbalanced forces.

Have you ever played tug-of-war? Two teams hold opposite ends of a rope. The players pull the rope toward them. If each team is pulling the rope with equal force, the forces are balanced. Neither team moves forward. If one team pulls with greater force, then the forces are unbalanced and the rope moves.

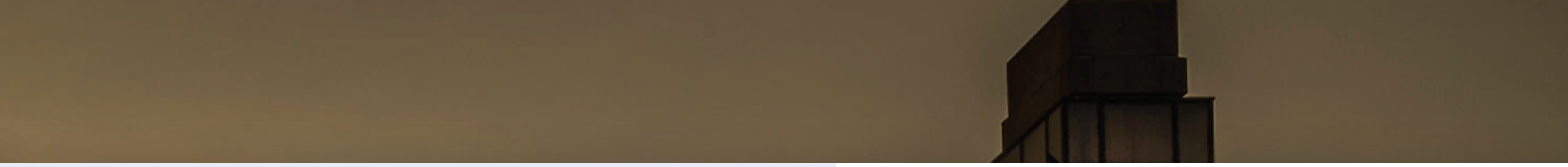
What are some examples of starting or stopping motion with a push?
Student answers will vary but may include any daily activities that involve a pushing motion.

What are some examples of starting or stopping motion with a pull?
Student answers will vary but may include any daily activities that involve a pulling motion.

Think about a time that you used force. What would that activity be like if there was no push or pull involved?
Student answers will vary but may include understanding that activities such as football or other sports would no longer be possible without the ability to push and pull.

Optional Digital Activity 7
Observe Like a Scientist
Tug-of-War
Go online to complete this activity.
Quick Code: egs4429

Concept 2.1: Starting and Stopping | 147



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What Makes Moving Objects Stop?

Activity 8

Analyze Like a Scientist

Stopping Motion

Quick Code: egs4091

Before you **read** the text, **look** at these words and phrases. **Think** about what the text will be about based on this list. Then, **answer** the question that follows.

- slow down
- force
- moving objects
- stop
- friction

Stopping Motion

Let's consider the effect of balanced and unbalanced forces in more detail. A book lying on a table is being pulled down by gravity and pushed up by the force the table exerts. When the forces on an object are balanced, the object does not move.

When the forces on an object are unbalanced, the object could start moving, move faster or slower, or change direction. If force causes motion, how does an object in motion STOP?

Life Skills I can use information to solve a problem.

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DIGITAL

Activity 8

Analyze Like a Scientist

Stopping Motion

Quick Code: egst4091

What Makes Moving Objects Stop?

Activity 8

Analyze Like a Scientist

20 min

Stopping Motion

Purpose

Students consider what they know about force causing motion to construct an explanation for the opposite effect: What causes an object to stop moving?

Instructional Focus

In this activity, students analyze a text about stopping motion to predict the effect of energy changes caused by collisions.

Life Skills **Problem-Solving**

Strategy

Before students read the text, give them the following words and have them identify those words in the text. Call on several students to share their predictions with the class.

- Slow down
- Force
- Moving objects
- Stop
- Friction

Lesson 3, *continued*

Have students highlight the following sentence from the text: Moving objects only stop when a force of the same size is applied to them in the opposite direction from which they are moving.

After students have completed the reading, ask them to construct an explanation for how an object stops moving using four or more of the words in the list at the beginning of the activity.

ASK *When a car runs into a wall, what can you assume about the size of the force of the car compared to the size of the force of the wall? Because the car stops moving, you can assume that the force exerted by the wall is the same size as the force of the moving car.*

Differentiation

ADVANCED LEARNERS

Provide students with toy cars. In groups, challenge students to see whose car can roll the farthest. Give each group the same car, but challenge students to create their own "track" with the least friction.

APPROACHING LEARNERS

For students who need more practice understanding the concept of friction, have them experiment rolling a ball on different surfaces. Have them use a smooth surface, a bumpy surface, and a rough surface. Have them observe what happens to the ball on the different surfaces.

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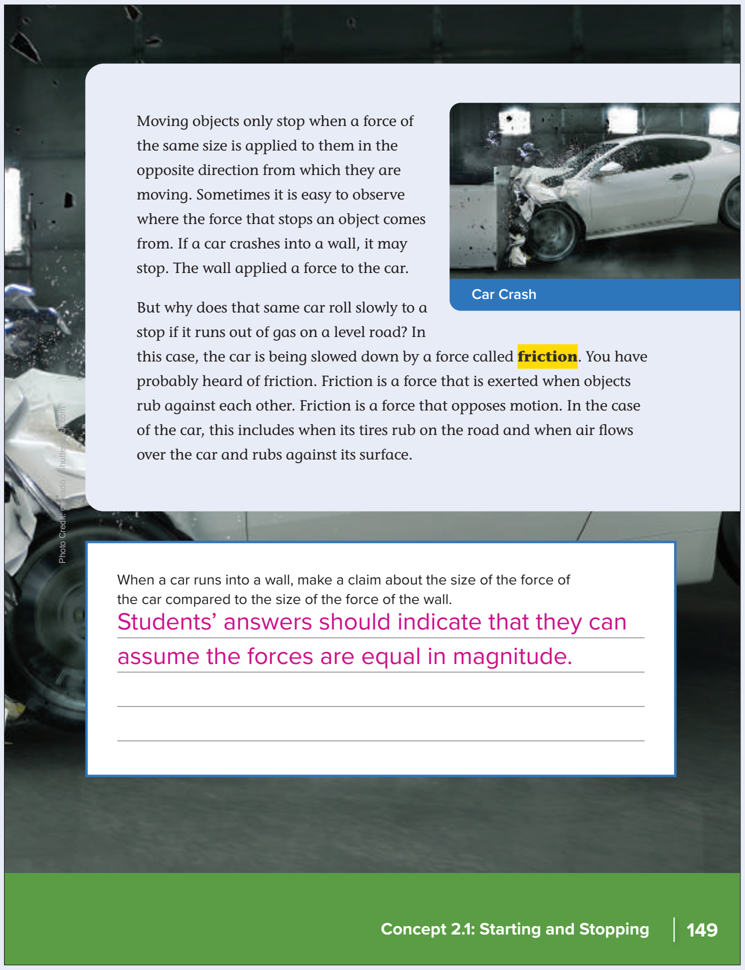


Moving objects only stop when a force of the same size is applied to them in the opposite direction from which they are moving. Sometimes it is easy to observe where the force that stops an object comes from. If a car crashes into a wall, it may stop. The wall applied a force to the car.

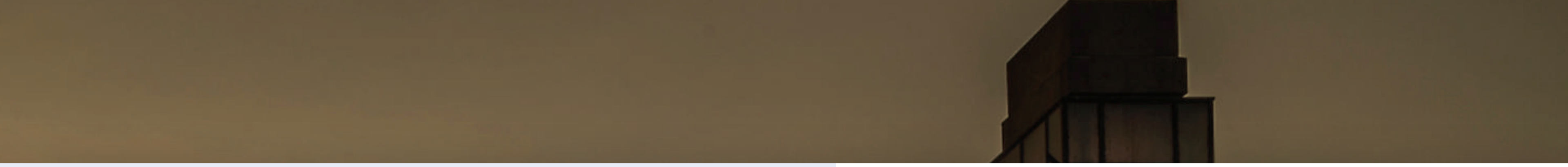
Car Crash

But why does that same car roll slowly to a stop if it runs out of gas on a level road? In this case, the car is being slowed down by a force called **friction**. You have probably heard of friction. Friction is a force that is exerted when objects rub against each other. Friction is a force that opposes motion. In the case of the car, this includes when its tires rub on the road and when air flows over the car and rubs against its surface.

When a car runs into a wall, make a claim about the size of the force of the car compared to the size of the force of the wall.

Students' answers should indicate that they can assume the forces are equal in magnitude.

Concept 2.1: Starting and Stopping | 149



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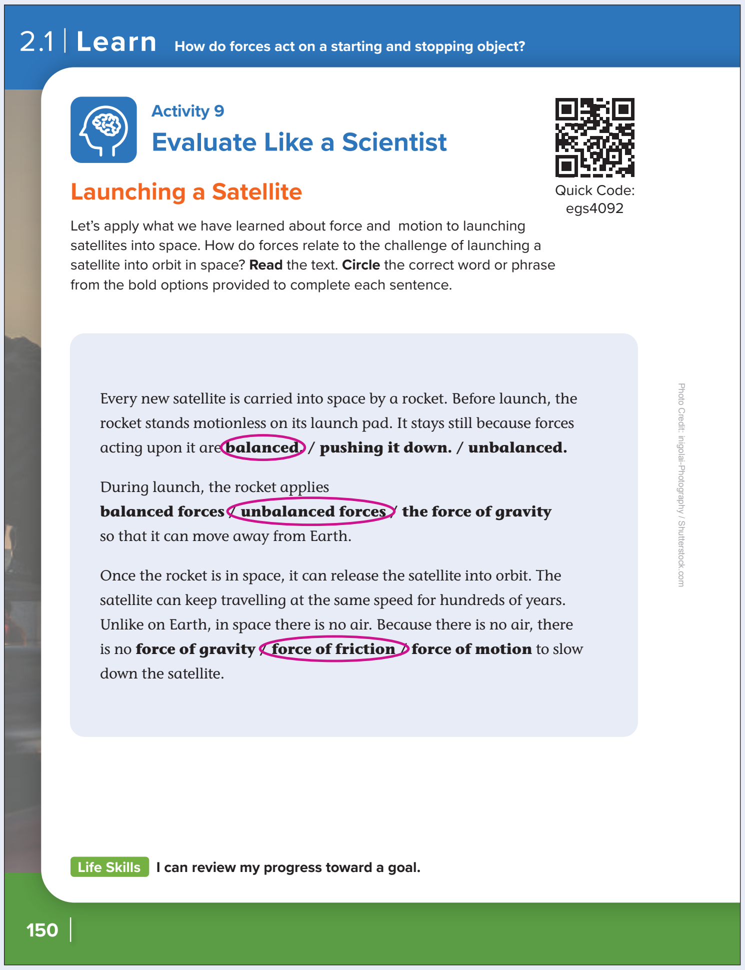

2.1 | Learn How do forces act on a starting and stopping object?

Activity 9

Evaluate Like a Scientist

Quick Code: egs4092

Launching a Satellite

Let's apply what we have learned about force and motion to launching satellites into space. How do forces relate to the challenge of launching a satellite into orbit in space? **Read** the text. **Circle** the correct word or phrase from the bold options provided to complete each sentence.

Every new satellite is carried into space by a rocket. Before launch, the rocket stands motionless on its launch pad. It stays still because forces acting upon it are **balanced / pushing it down. / unbalanced.**

During launch, the rocket applies **balanced forces / unbalanced forces / the force of gravity** so that it can move away from Earth.

Once the rocket is in space, it can release the satellite into orbit. The satellite can keep travelling at the same speed for hundreds of years. Unlike on Earth, in space there is no air. Because there is no air, there is no **force of gravity / force of friction / force of motion** to slow down the satellite.

Photo Credit: Ingolse Photography / Shutterstock.com

Life Skills I can review my progress toward a goal.

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DIGITAL

Activity 9

Evaluate Like a Scientist

Launching a Satellite

Quick Code: egst4092

Activity 9

Evaluate Like a Scientist

10 min

Launching a Satellite

Purpose

This formative assessment provides an opportunity to check for student understanding of how balanced and unbalanced forces affect motion.

Instructional Focus

In this activity, students apply their understanding of balanced and unbalanced forces to construct an explanation about how forces acting on a space probe can be used to predict how its energy changes with changes to its motion.

Life Skills **Self-Management**

Strategy

Encourage students to review the previous reading passages before articulating their own understanding in this formative assessment. Students select the correct word or phrase from the list of options provided to complete each sentence.

After they have individually recorded answers, allow students to compare and discuss answers with a partner. Encourage students to review prior reading passages to clarify or correct their understanding as needed.

Teacher Reflection

- What content did my students struggle with during the Evaluate activity?
- What other activities demonstrating relationship between force and stopping motion could I include the next time I teach this lesson?

Lesson 4

What Is the Relationship between Force and Energy?

Activity 10
Investigate Like a Scientist

45 min

Hands-On Investigation: Rolling Cars

Purpose

After reading multiple examples of how forces affect motion, students now investigate and directly observe this relationship. Through observation, students conclude that applying large force results in a large amount of kinetic energy and a further distance traveled. Later in the unit, students will apply this relationship to their understanding of the impact of two objects colliding.

Instructional Focus

In this activity, students collect and analyze data about the distance model cars travel to construct an explanation about the relationship between force and kinetic energy in different scenarios.

Materials List (per group)

- Toy trucks, cars
- Measuring tape

HANDS-ON INVESTIGATION

Safety

- Follow all general lab safety rules.
- Do not eat or drink anything in the lab.
- Wear closed-toe shoes.
- Keep the toy cars and trucks on the ground. Do not launch them off desks and tables.

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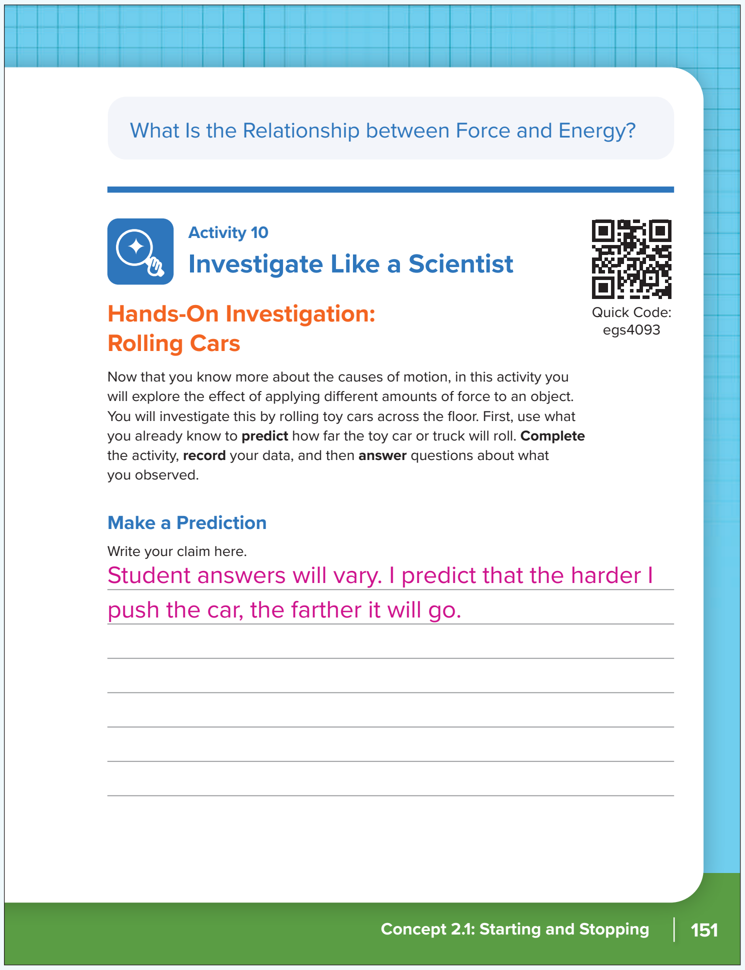

What Is the Relationship between Force and Energy?

Activity 10

Investigate Like a Scientist

Quick Code: egs4093

Hands-On Investigation: Rolling Cars

Now that you know more about the causes of motion, in this activity you will explore the effect of applying different amounts of force to an object. You will investigate this by rolling toy cars across the floor. First, use what you already know to **predict** how far the toy car or truck will roll. **Complete** the activity, **record** your data, and then **answer** questions about what you observed.

Make a Prediction

Write your claim here.

Student answers will vary. I predict that the harder I push the car, the farther it will go.

Concept 2.1: Starting and Stopping | 151

DIGITAL

Activity 10

Investigate Like a Scientist

Hands-On Investigation: Rolling Cars

Quick Code: egst4093

Lesson 4, *continued*

Activity Activator: Make a Prediction

Ask students to use prior experience to explain how the distance an object moves depends on the amount of force used to move it.

ASK *If you are playing catch with a friend and the friend moves farther away, would you have to throw the ball harder or softer for your friend to catch it?*

I would need to throw the ball harder for it to reach my friend that is farther away.

After some discussion, have students complete the activity by making a prediction about how far a toy car would roll if pushed.

Lesson 4, *continued*

Activity Procedure: What Will You Do?

1. Distribute an assortment of toy cars and trucks among student groups. Ask each group to find and agree on a way to measure the distance their toy cars will go (tape on the floor, yardstick, hand lengths, tiles, etc.). Have small groups work in their own space in the classroom to determine a starting point from which to roll the toy cars along the floor.
2. Have each group push a toy car hard. The groups should record the distance their toy car rolls. They should record their results numerically. Each group should conduct multiple trials and calculate the average.

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2.1 | Learn How do forces act on a starting and stopping object?

What materials do you need? (per group)

- Toy trucks, cars
- Measuring tape

HANDS-ON INVESTIGATION

What Will You Do?

1. Gather your toy cars and trucks.
2. Plan a way to measure the distance your cars will travel, and create a simple sketch of your plan.
3. Push a toy car hard from a starting point.
4. Record the distance the toy car rolls.
5. Repeat steps 3 and 4 several times, and find the average.
6. Predict what will happen if you push your toy car very gently.
7. Push a toy car very gently from the starting point you used in step 3.
8. Record the distance the toy car rolls.
9. Repeat step 7 several times, and find the average.

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Record your data in the table.

Trial	Type of Push	Distance
1	Hard	Answers will vary.
2	Hard	Answers will vary.
3	Hard	Answers will vary.
4	Hard	Answers will vary.
Average hard push distance		
5	Gentle	Answers will vary.
6	Gentle	Answers will vary.
7	Gentle	Answers will vary.
8	Gentle	Answers will vary.
Average gentle push distance		

Concept 2.1: Starting and Stopping | 153

Lesson 4, *continued*

3. Ask each group to predict and agree on what they think will happen if they push their toy car very gently. Have the groups push softly to see if their prediction was correct. The groups should record the distance that their car went. They should record their results numerically. Again, each group should conduct multiple trials and calculate the average.

4. After students have collected the data, have a representative from each group share the type of vehicle they used and the average distance for both types of pushes. This can be shared verbally and/or written on the board.

Lesson 4, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *Did the results of the investigation provide evidence that supported or did not support your hypothesis?*
  My hypothesis that the car pushed hard would travel farther than the car pushed gently was verified by our results.
- *Describe how you know.*
  Specifically, the car that I pushed hard traveled on average 3 meters, and the car that was pushed gently traveled on average 1 meter.
- *What was the source of the variation in each of your trials?*
  In our hard-push trials, we could not push it the same every time, so that's why James's push went over 5 meters and another only went 3 meters.
- *Could the distance each car traveled have changed if you had used a different car or truck?*
  Student answers will vary, but they should generally note some things that could have changed. Yes, the distance the car traveled could have changed if we used a different car or truck. If it was bigger, it would not have traveled as far. If it was smaller, it would have traveled farther.
- *Why did each car stop where it did?*
  Student answers will vary, but they should note that the car was slowing down as it approached the point where it stopped. The car started out quickly but slowed down from friction between the tires and the ground. Eventually, those forces brought the car to a complete stop.

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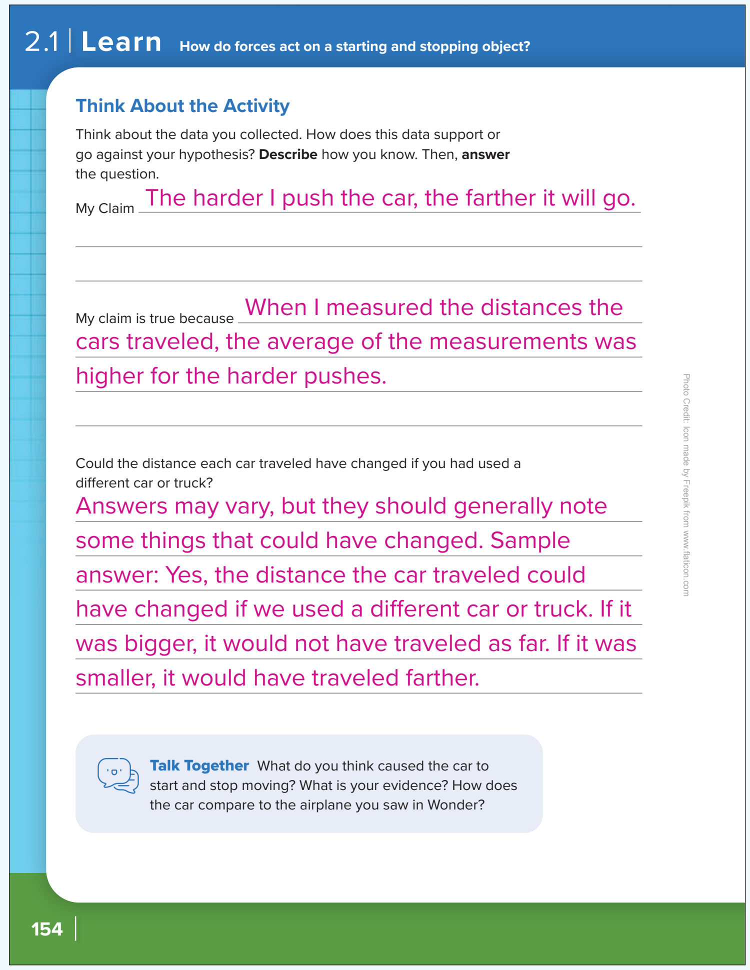
2.1 | Learn How do forces act on a starting and stopping object?

Think About the Activity

Think about the data you collected. How does this data support or go against your hypothesis? **Describe** how you know. Then, **answer** the question.

My Claim The harder I push the car, the farther it will go.

My claim is true because When I measured the distances the cars traveled, the average of the measurements was higher for the harder pushes.

Could the distance each car traveled have changed if you had used a different car or truck?

Answers may vary, but they should generally note some things that could have changed. Sample answer: Yes, the distance the car traveled could have changed if we used a different car or truck. If it was bigger, it would not have traveled as far. If it was smaller, it would have traveled farther.

Talk Together What do you think caused the car to start and stop moving? What is your evidence? How does the car compare to the airplane you saw in Wonder?

Photo Credit: Icon made by Freepik from www.flaticon.com

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ASK

- *What additional questions do you have about starting and stopping? Choose one of your questions and explain how you could learn information to help you answer the question.*
  Students' questions will vary, but they should provide at least two questions and provide a means to test one of their questions. I wonder about how friction works. I also wonder whether we could have the car travel the same distance every time. To investigate the second question, I would see if we could make a machine that would push the car with the same force every time. Then, I would see if that resulted in the car traveling the same distance each time.

Return to the video of the Truck versus Airplane in Activity 2. Show the video portion depicting the truck starting and stopping (1:03-1:54). Place students in pairs. Instruct them to turn to their partners and describe the forces acting on the truck to start and stop its motion. At this point, students do not need quantitative values, but they should indicate that a force greater than the force they applied to the cars would be needed, as the truck is heavier than the toy car. Students may also think that the truck stops due to friction, similar to the toy car in their testing. The next activity will support students with additional evidence related to why objects stop or change their motion.

Lesson 5

Activity 11
Observe Like a Scientist

10 min

Energy, Work, and Force

Purpose

Students now have a solid understanding of what motion is and which factors are involved in starting, stopping, and changing motion. Before students can begin learning about more sophisticated phenomena associated with motion, students must first explore the relationship between force, energy, and work.

Instructional Focus

In this activity, students give an explanation of the relationship between force and energy in the context of work.

Life Skills **Respect for Diversity**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before students read the text and watch the video, introduce students to the term *work* as it is applied in physics.

ASK

- *How would you define the word work? Student answers will vary but likely students will offer chores or schoolwork as examples of work.*
- *How do you think the scientific meaning of the word work might be different from how we use it in daily conversation? Student answers will vary but most students will be unfamiliar with the term work as it is used in physics.*

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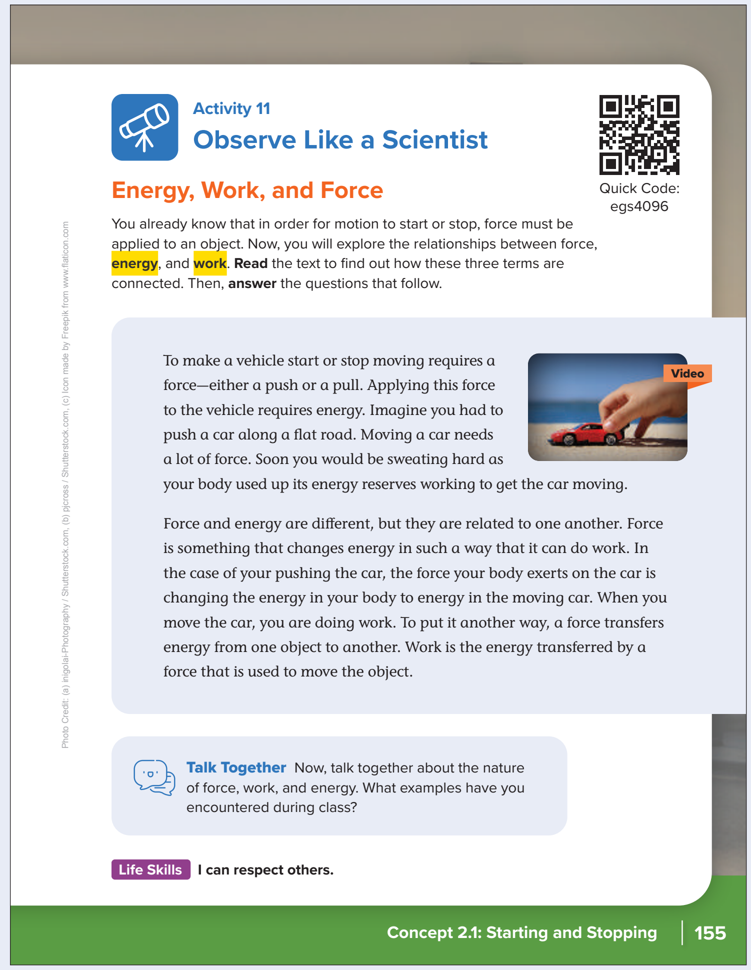

Activity 11

Observe Like a Scientist

Energy, Work, and Force

Quick Code: egs4096

You already know that in order for motion to start or stop, force must be applied to an object. Now, you will explore the relationships between force, **energy**, and **work**. **Read** the text to find out how these three terms are connected. Then, **answer** the questions that follow.

To make a vehicle start or stop moving requires a force—either a push or a pull. Applying this force to the vehicle requires energy. Imagine you had to push a car along a flat road. Moving a car needs a lot of force. Soon you would be sweating hard as your body used up its energy reserves working to get the car moving.

Video

Force and energy are different, but they are related to one another. Force is something that changes energy in such a way that it can do work. In the case of your pushing the car, the force your body exerts on the car is changing the energy in your body to energy in the moving car. When you move the car, you are doing work. To put it another way, a force transfers energy from one object to another. Work is the energy transferred by a force that is used to move the object.

Talk Together Now, talk together about the nature of force, work, and energy. What examples have you encountered during class?

Life Skills **I can respect others.**

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Concept 2.1: Starting and Stopping | 155

Photo Credit: pjcross / Shutterstock.com

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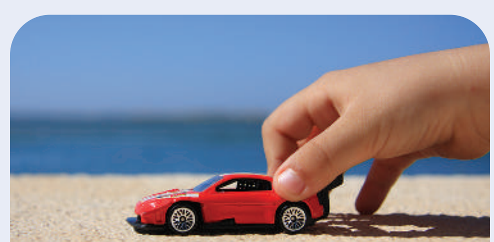
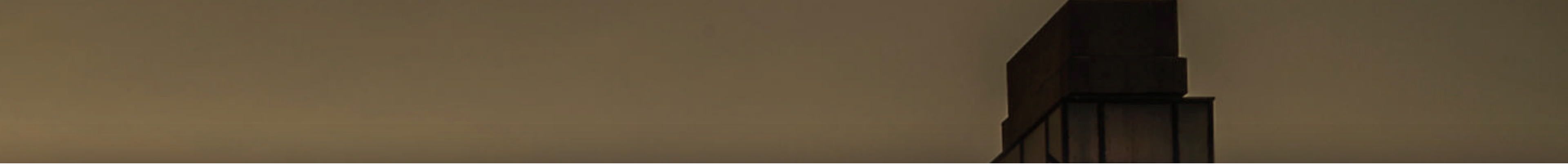


Activity 11
Analyze Like a Scientist
Energy, Work, and Force

Quick Code:
egst4095



Lesson 5, *continued*

As a whole class or in small groups, guide the students though the text. Stop to check for understanding and discuss misconceptions.

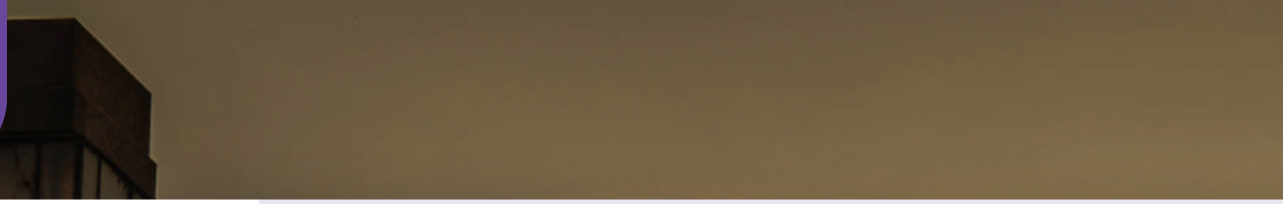
Once the class is finished reading the text, revisit the discussion of the term *work* in science versus how it is used in conversation. Facilitate a class discussion about the various definitions of *work*.

ASK

- *How does the reading passage define work?*
  Work is the measure of energy transfer that occurs when an object is moved over a distance.
- *What do these two uses of the word work have to do with one another?*
  Student answers will vary but most students will understand that the daily use of the word implies using energy to complete a task and involves some movement.
- *How is work related to energy and force?*
  Force requires energy. Energy is the ability to do work.

Be sure to provide or confirm accurate responses so that students do not reinforce misunderstandings.

If available, provide students with time to watch the video in small groups or as a whole class.



Lesson 5, *continued*

Scientific Explanation

Activity 12
Record Evidence Like a Scientist

20 min

Truck versus Airplane

Purpose
In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus
In this activity, students review and discuss their initial explanations about the investigative phenomenon Truck versus Airplane, based on the information about forces and motion acquired in the previous activities.

Life Skills **Creativity**

Strategy
Display the investigative phenomenon of the Truck versus Airplane video and the Can You Explain? question. Ask students to discuss and share with the class or a partner their explanation for the investigative phenomenon Truck versus Airplane.

After allowing students to discuss,

ASK *How can this explanation help you answer the Can You Explain? question?*

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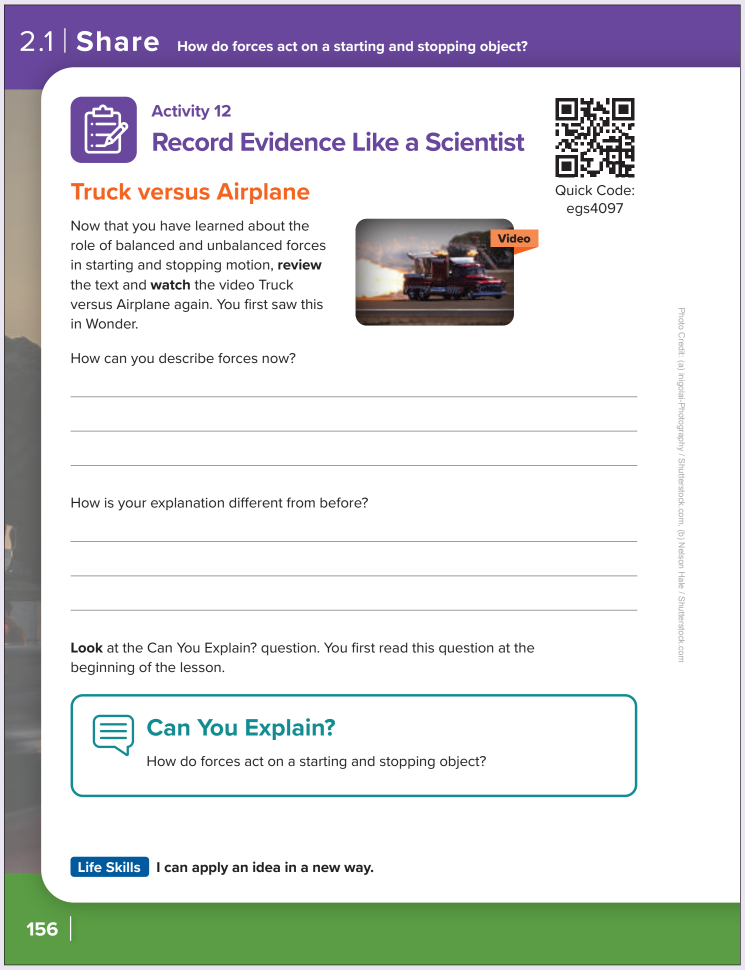

2.1 | Share How do forces act on a starting and stopping object?

Activity 12
Record Evidence Like a Scientist

Quick Code: egs4097

Truck versus Airplane

Now that you have learned about the role of balanced and unbalanced forces in starting and stopping motion, **review** the text and **watch** the video Truck versus Airplane again. You first saw this in Wonder.

Video

How can you describe forces now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?
How do forces act on a starting and stopping object?

Life Skills I can apply an idea in a new way.

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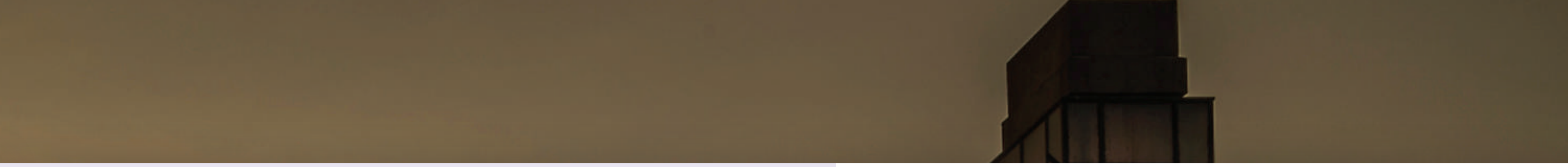
Activity 12
Record Evidence Like a Scientist
Truck versus Airplane

Quick Code:
egst4097



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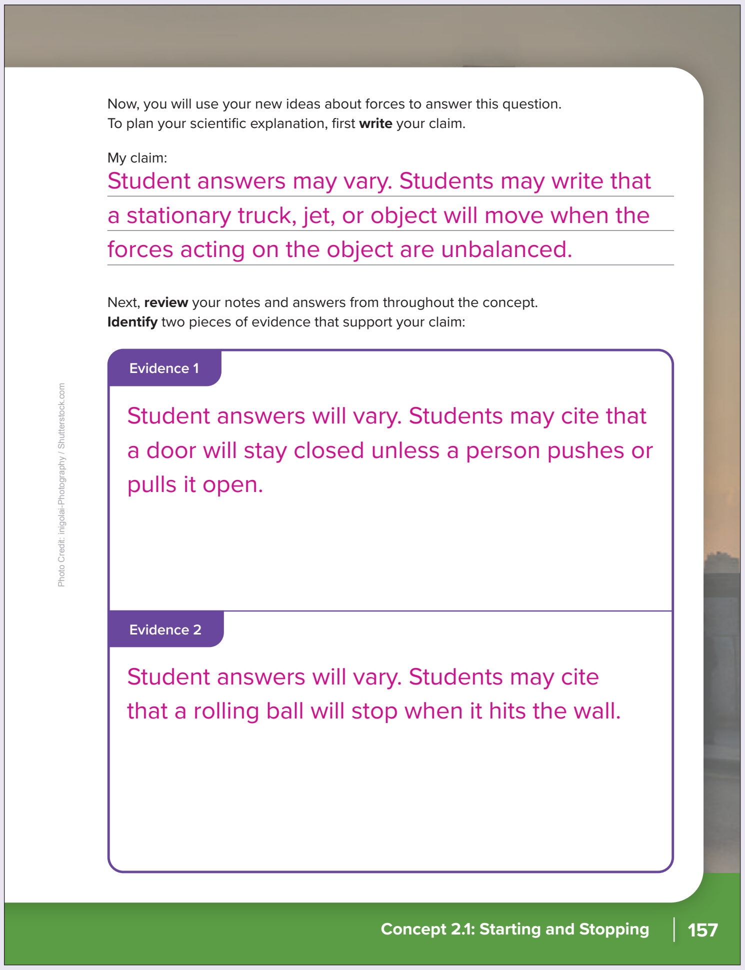
Now, you will use your new ideas about forces to answer this question.
To plan your scientific explanation, first **write** your claim.

My claim:
Student answers may vary. Students may write that a stationary truck, jet, or object will move when the forces acting on the object are unbalanced.

Next, **review** your notes and answers from throughout the concept.
Identify two pieces of evidence that support your claim:

Evidence 1

Student answers will vary. Students may cite that a door will stay closed unless a person pushes or pulls it open.

Evidence 2

Student answers will vary. Students may cite that a rolling ball will stop when it hits the wall.

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Concept 2.1: Starting and Stopping | 157

Lesson 5, *continued*

Invite students to share their thoughts and explanations. Guide the discussion to incorporate information taught during this concept about friction, energy, and force. Review these ideas as they apply to this example and compare them to investigations conducted by the students.

After providing scaffolding to the students, for those students able to do so, allow them to construct a full scientific explanation. They can write, draw, or orally describe their claim, evidence, and reasoning.

As students would have already reviewed sample scientific explanations in earlier units, they should be familiar with the claim, reasoning and evidence framework. You may want to review the following:

Claim is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with yes or no.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use data that support your claim. Leave out information that doesn't support the claim.

Students will be introduced to the Reasoning part of the framework in future concepts.

Review student responses in the graphic organizer:

My Claim:
Student answers may vary. Students may write that a stationary truck, jet, or object will move when the forces acting on the object are unbalanced.

Evidence 1:
Student answers will vary. Students may cite that a door will stay closed unless a person pushes or pulls it open.

Evidence 2:
Student answers will vary. Students may cite that a rolling ball will stop when it hits the wall.

Lesson 5, *continued*

Have students generate a scientific explanation to answer the Can You Explain? question.

Can You Explain?

How do forces act on a starting and stopping object?

Sample student response:

Objects require a force to move them. Force is a push or pull. When all the forces acting on an object are equal, the object does not move. For an object to move, the forces acting on it need to change. The forces on a stationary truck are balanced. Once these forces are no longer equal, the truck will begin to move. A truck moving forward needs a force pulling it back to make it stop. The truck will stop moving when the forces become equal again. During the Hands-On Investigation: Rolling Cars, we saw that different amounts of forces led to different changes in motion. A hard push or force moved objects farther distances. Also, friction acted on the car, slowing it down. Friction acted differently on each car because of the cars' different sizes and shapes. Friction and the force of the parachute helps stop the truck.

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2.1 | **Share** **How do forces act on a starting and stopping object?**

Now, **write** your scientific explanation.

The forces acting on a truck with jet engines cause it to start and stop because...

See sample student responses in Teacher Materials.

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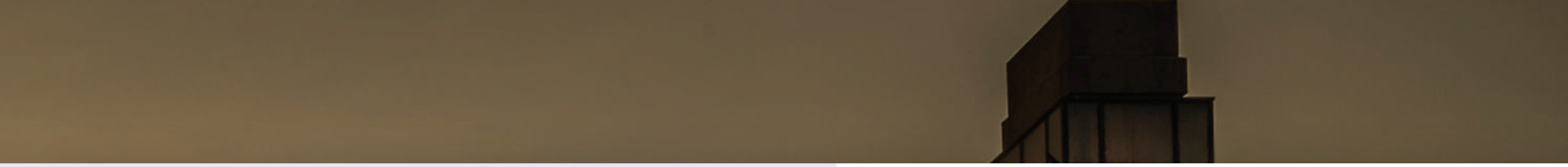

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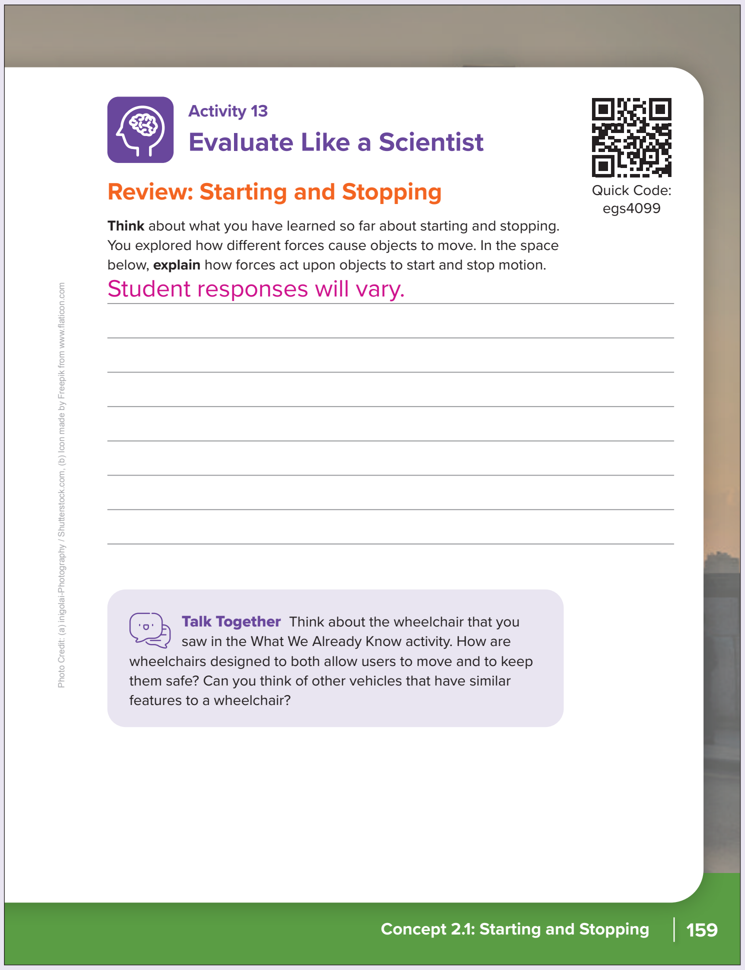

Activity 13
Evaluate Like a Scientist

Quick Code: egs4099

Review: Starting and Stopping

Think about what you have learned so far about starting and stopping. You explored how different forces cause objects to move. In the space below, **explain** how forces act upon objects to start and stop motion.

Student responses will vary.

Talk Together Think about the wheelchair that you saw in the What We Already Know activity. How are wheelchairs designed to both allow users to move and to keep them safe? Can you think of other vehicles that have similar features to a wheelchair?

DIGITAL

Activity 13
Evaluate Like a Scientist
Review: Starting and Stopping

Quick Code:
egst4099

Review and Assess

Activity 13
Evaluate Like a Scientist

15 min

Review: Starting and Stopping

Purpose

The final activity of the concept asks students to review and explain the main ideas of starting and stopping motion.

Instructional Focus

Students summarize their learning about starting and stopping with a written explanation and by completing a concept summative assessment.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas. You may also assign students the summative assessment for this concept.

In the summative concept assessment, students will determine the relationship between force and energy and what makes an object stop or start moving.

CONCEPT

2.2

Energy and Motion

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Concept Objectives

By the end of this concept, students should be able to:

- Ask questions that can be investigated to determine the form of energy in a system or for an object.
- Use patterns and logical reasoning to predict if objects have kinetic and/or potential energy.
- Communicate information about different sources of potential energy that can be converted to kinetic energy by objects and construct an explanation that energy is conserved during these conversions.

Quick Code:
egst4100

Photo Credit: Toa55 / Shutterstock.com

Key Vocabulary

new: chemical energy, gravitational potential energy, kinetic energy, potential energy, thermal energy

review: energy, friction, work

Academic Vocabulary

convert

Quick Code:
egst4101

Key Vocabulary Strategy

Associations

Write the vocabulary words as headers of different columns on a board. Then, ask students about other terms they could think of that relate to these vocabulary words. Have the students discuss whether some points should be moved or removed.

Academic Vocabulary Strategy

Convert

Divide the class into small groups and place each group in charge of learning a definition for the term *convert* in a different scenario. Then, each group should nominate a member to explain the meaning to the rest of the class. Next, have the students discuss and develop a more general definition of *convert* based on the specific definitions they have learned.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	15 min
		Activity 3	20 min
		Activity 4	15 min
Learn	Lesson 2	Activity 5	15 min
		Activity 6	15 min
	Lesson 3	Activity 7	25 min
		Activity 8	20 min
	Lesson 4	Activity 10	20 min
		Activity 11	25 min
Share	Lesson 5	Activity 12	20 min
		Activity 13	10 min
		Activity 14	15 min

Content Background

Energy

Work is the transfer of energy that occurs when an object is moved. Energy is the capacity to do work. In the previous concept, students learned how to use these familiar terms within a scientific context. Now students will use this foundational understanding to begin thinking about energy in its different forms and types, as well as how energy can be changed.

The amount of energy in the world is constant. The law of conservation of energy states that energy is neither created nor destroyed. When energy is used, it does not diminish or disappear; it simply changes forms. Students may think that energy can be lost or used up, but in reality, energy is constantly being passed from object to object or system to system, often changing forms and types in the process.

Light energy from the sun becomes chemical energy in plants, which are consumed by people. A bicyclist eats a salad and then uses this chemical energy to compete in a race. As she pedals, she is turning chemical energy into mechanical energy. Some of this energy is lost as heat energy when the rubber tires of the bicycle encounter friction with the road. These are examples of how energy is constantly changing forms all around us.

Potential Energy and Kinetic Energy

Scientists divide energy into two main forms: potential energy and kinetic energy. In many investigations that students conduct for the remainder of this unit, they will convert potential energy into kinetic energy. Understanding the difference between these two terms is critical to being able to explain their data and outcomes.

Potential energy is stored energy. Potential energy is the energy possessed by something because of its position. Some examples of types of energy that can be stored are chemical (stored inside food), elastic (an archer's stretched bow), and gravitational (a still marble at the top of a ramp).

Content Background, *continued*

Kinetic energy is energy of motion. All moving objects have kinetic energy. Types of kinetic energy include radiant, thermal, and sound. Radiant energy is energy that travels in electromagnetic waves, such as X-rays or sunlight. Thermal energy is the vibration of atoms within substances; these vibrations create heat. Sound is another form of energy that utilizes waves. Sound waves are vibrations in the particles of a medium, such as air, water, or wood. Sound energy is generally less powerful than the other types of energy.

Mechanical energy can be either potential or kinetic. Mechanical energy is energy objects have because of their motion or position. Think of a ball rolling down a hill. At the top of the hill, before it begins to roll, the ball has only potential energy from the pull of gravity. As the ball rolls, its potential energy is converted to kinetic energy. In a perfect system, the ball's mechanical energy would not change as it rolls—each unit of potential energy would change to an equivalent amount of kinetic energy. In reality, however, forces, such as friction and air resistance, push against the ball as it rolls, converting its mechanical energy into thermal energy and sound and causing it to slow down.

Types of Energy

There are many different types of energy. Some types of energy people can sense directly. These include light, heat, and sound. Some types of energy are invisible; we can see only what results from using them, such as how an object changes or where it moves. Chemical energy is the energy stored in the bonds between atoms and released during chemical changes. Biomass, fossil fuels, and coal are examples of substances that contain large amounts of chemical energy. Another type of energy, nuclear energy, is stored in the nuclei of atoms. Electricity, or electrical energy, is energy that results from the movement of charged particles.

At the end of this concept, students should understand that different forms and types of energy exist and that changes to energy can occur. However, students at this level are not expected to be able to explain the complex nature of how energy behaves at the atomic level.

Lesson 1

Activity 1
Can You Explain?

10 min

How do moving objects get energy?

Purpose

This activity draws on students' prior knowledge of energy and motion by asking students to connect the two ideas and consider how moving objects get energy. Activating students' prior knowledge around the topic will allow them to build on what they already know about energy and motion as they make connections to designing safety features in a car.

Instructional Focus

In this activity, students will use prior knowledge to explain the concept of the energy of objects in motion.

Strategy

Students may have some initial ideas about how to answer the question (see sample student response in the Student Materials page). By the end of the concept, students should be able to construct a scientific explanation that includes evidence from the concept activities.

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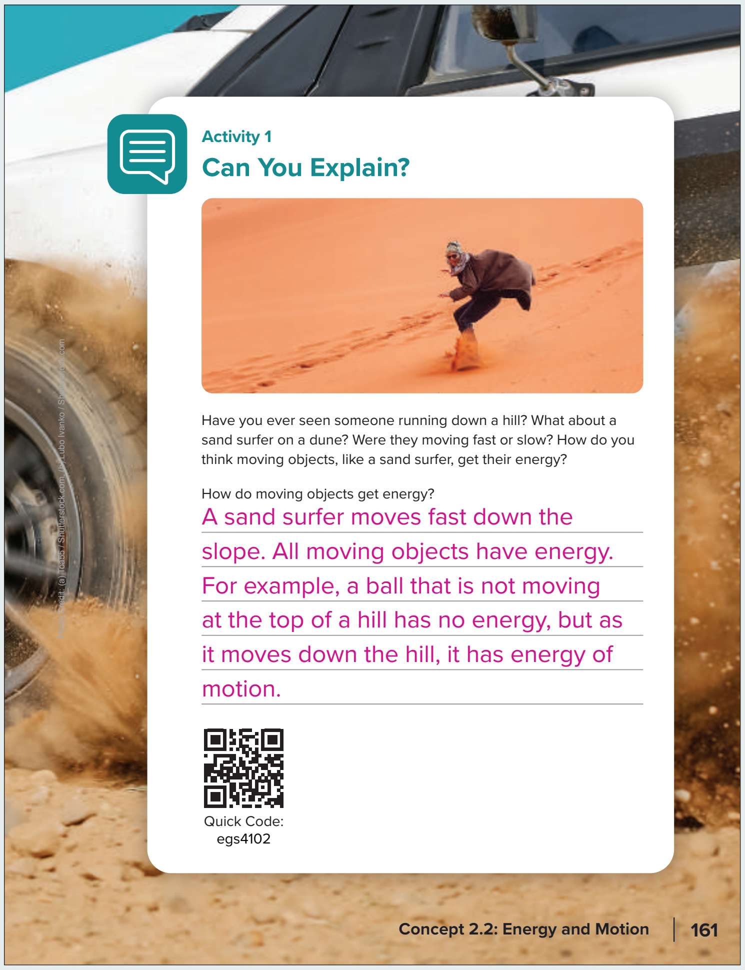
Activity 1
Can You Explain?

Have you ever seen someone running down a hill? What about a sand surfer on a dune? Were they moving fast or slow? How do you think moving objects, like a sand surfer, get their energy?

How do moving objects get energy?

A sand surfer moves fast down the slope. All moving objects have energy. For example, a ball that is not moving at the top of a hill has no energy, but as it moves down the hill, it has energy of motion.

Quick Code:
egs4102

Concept 2.2: Energy and Motion | 161

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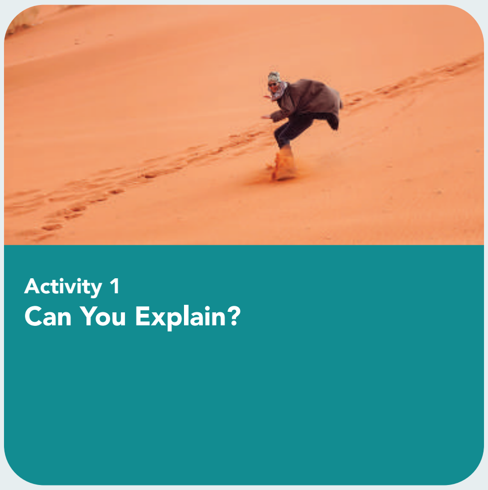

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Lesson 1, *continued*

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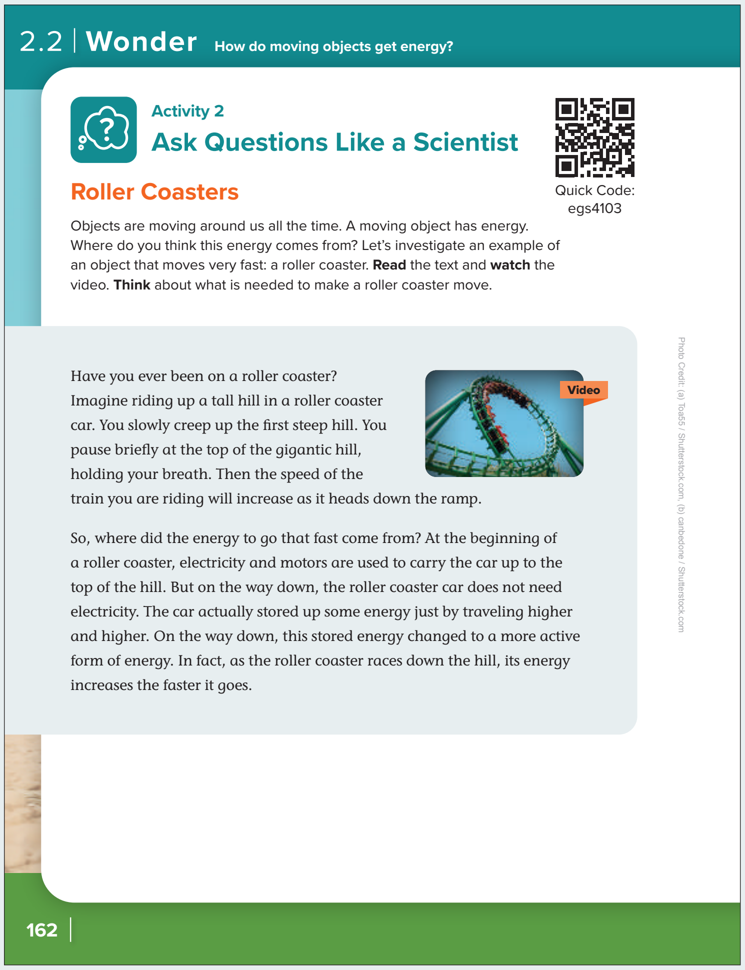

2.2 | **Wonder** How do moving objects get energy?

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4103

Roller Coasters

Objects are moving around us all the time. A moving object has energy. Where do you think this energy comes from? Let's investigate an example of an object that moves very fast: a roller coaster. **Read** the text and **watch** the video. **Think** about what is needed to make a roller coaster move.

Video

Have you ever been on a roller coaster? Imagine riding up a tall hill in a roller coaster car. You slowly creep up the first steep hill. You pause briefly at the top of the gigantic hill, holding your breath. Then the speed of the train you are riding will increase as it heads down the ramp.

So, where did the energy to go that fast come from? At the beginning of a roller coaster, electricity and motors are used to carry the car up to the top of the hill. But on the way down, the roller coaster car does not need electricity. The car actually stored up some energy just by traveling higher and higher. On the way down, this stored energy changed to a more active form of energy. In fact, as the roller coaster races down the hill, its energy increases the faster it goes.

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Photo Credit: canbedone / Shutterstock.com

DIGITAL

Activity 2
Ask Questions Like a Scientist
Roller Coasters

Quick Code: egst4103

Investigative Phenomenon

Activity 2
Ask Questions Like a Scientist

15 min

Roller Coasters

Purpose

The Investigative Phenomenon presents an engaging scenario—sometimes familiar and sometimes unfamiliar—to spark student curiosity about the world around them. In this activity, students think about a roller coaster in motion and discuss the energy that makes it move.

Instructional Focus

In this activity, students read a text and watch a video about a roller coaster, make observations, and ask questions about what happens to the energy used to make it move.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the video, text has been provided to support learning.

Direct students to read the text and watch the video *Roller Coasters* to relate the motion of an object to the cause of that motion. Ensure that students can apply the basic principle that the roller coaster's energy is related to its speed.

Lesson 1, *continued*

After the video, have students think-pair-share questions they have regarding the energy used to get the roller coaster moving and what happened to that energy as it moved. Students should generate their ideas in the form of questions they have about the roller coaster.

The example of the roller coaster will be revisited elsewhere in the concept, so use the ideas they generate here as an indicator of how their understanding develops as they progress through the concept.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?

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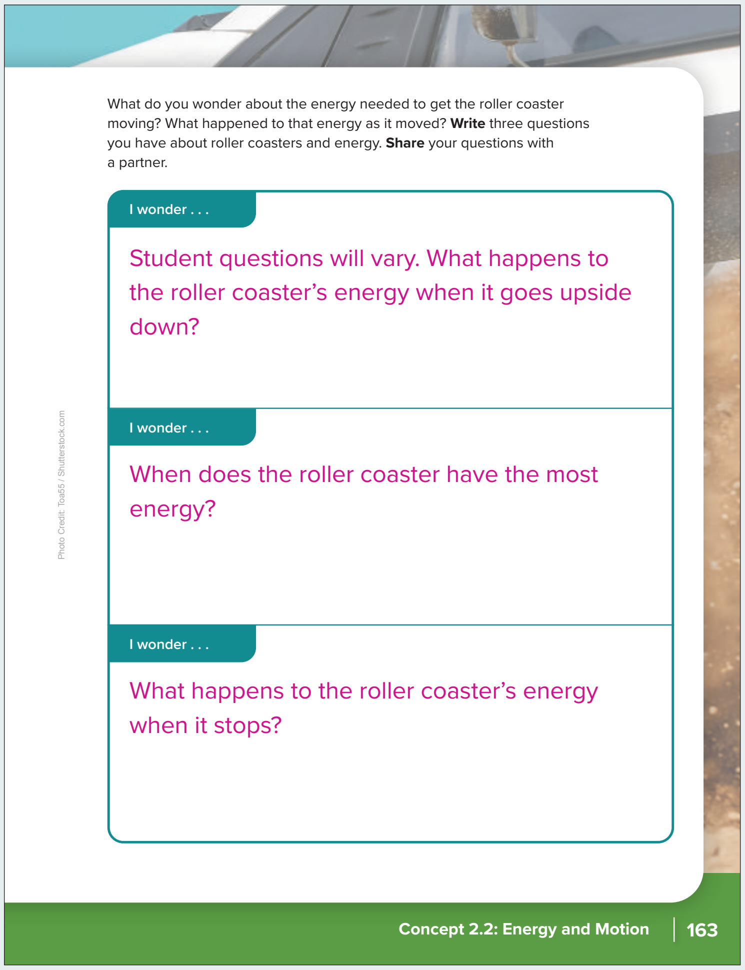
What do you wonder about the energy needed to get the roller coaster moving? What happened to that energy as it moved? **Write** three questions you have about roller coasters and energy. **Share** your questions with a partner.

I wonder . . .

Student questions will vary. What happens to the roller coaster's energy when it goes upside down?

I wonder . . .

When does the roller coaster have the most energy?

I wonder . . .

What happens to the roller coaster's energy when it stops?

Concept 2.2: Energy and Motion | 163

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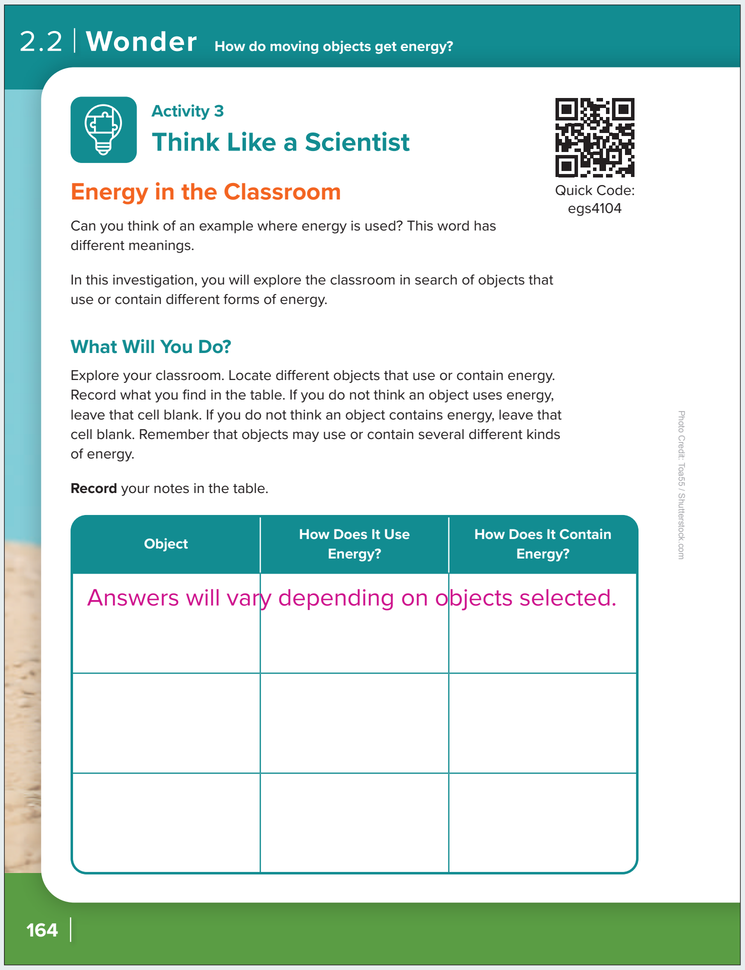

2.2 | **Wonder** How do moving objects get energy?

Activity 3

Think Like a Scientist

Energy in the Classroom

Can you think of an example where energy is used? This word has different meanings.

In this investigation, you will explore the classroom in search of objects that use or contain different forms of energy.

Quick Code: egs4104

What Will You Do?

Explore your classroom. Locate different objects that use or contain energy. Record what you find in the table. If you do not think an object uses energy, leave that cell blank. If you do not think an object contains energy, leave that cell blank. Remember that objects may use or contain several different kinds of energy.

Record your notes in the table.

Object	How Does It Use Energy?	How Does It Contain Energy?
Answers will vary depending on objects selected.		

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Activity 3
Think Like a Scientist
Energy in the Classroom

Quick Code: egst4104

Photo Credit: Vasilyev Alexandr / Shutterstock.com

Activity 3

Think Like a Scientist

20 min

Energy in the Classroom

Purpose

In this activity, students explore a familiar environment—the classroom—in search of objects that have energy. As they compare objects, students consider that energy exists in different forms.

Instructional Focus

In this activity, students communicate prior knowledge of energy and apply it to identifying different forms of energy in objects found around the classroom.

Life Skills **Decision-Making**

Activity Activator

Students will be familiar with the idea of energy from everyday use of the word, as well as in their science classes.

This activity is designed to introduce students to how the term *energy* is used in science by exploring concrete examples of energy in its different forms.

Students will use this as a foundation for building an understanding of different forms of energy that can be applied during later reading and Hands-On Investigations.

Lesson 1, *continued*

Activity Procedure: What Will You Do?

- In this activity, students explore the classroom to locate examples of objects that use or contain different forms of energy. These include any number of common classroom or laboratory objects. Examples:
    - Mechanical energy: anything that moves, such as pencil sharpeners, clocks with moving hands, or fans
    - Chemical energy: food and batteries or battery-operated objects, such as clocks, cell phones, or portable music players
    - Thermal (heat) energy: anything that gives off heat, such as a radiator or matches
    - Radiant (light) energy: anything that gives off light, such as ceiling lights, flashlights, or computer screens
    - Electrical energy: anything powered by electricity, such as computers, overhead projectors, or televisions
    - Sound energy: anything that produces sound, such as musical instruments, radios, or alarm bells
- Remind students that energy is found everywhere, including in the classroom. Give students 5 or 10 minutes to explore the classroom, trying to locate different objects that use or contain energy. As they explore, students should organize their notes in their three-column charts; if they do not think an object both uses AND contains energy, they should leave the appropriate cell blank. Encourage the students to use descriptive words such as *loud, hot,* and *bright* when recording their data. Remind students that objects may use or contain several different kinds of energy.
- As students explore, circulate to make sure they are behaving appropriately and not handling any dangerous objects. When ready, regroup as a class and have volunteers share their notes to discuss the objects with energy found in the room.

ASK *Do you see any similarities between multiple objects on your list? How might you group or categorize your list?*
Student answers will vary.

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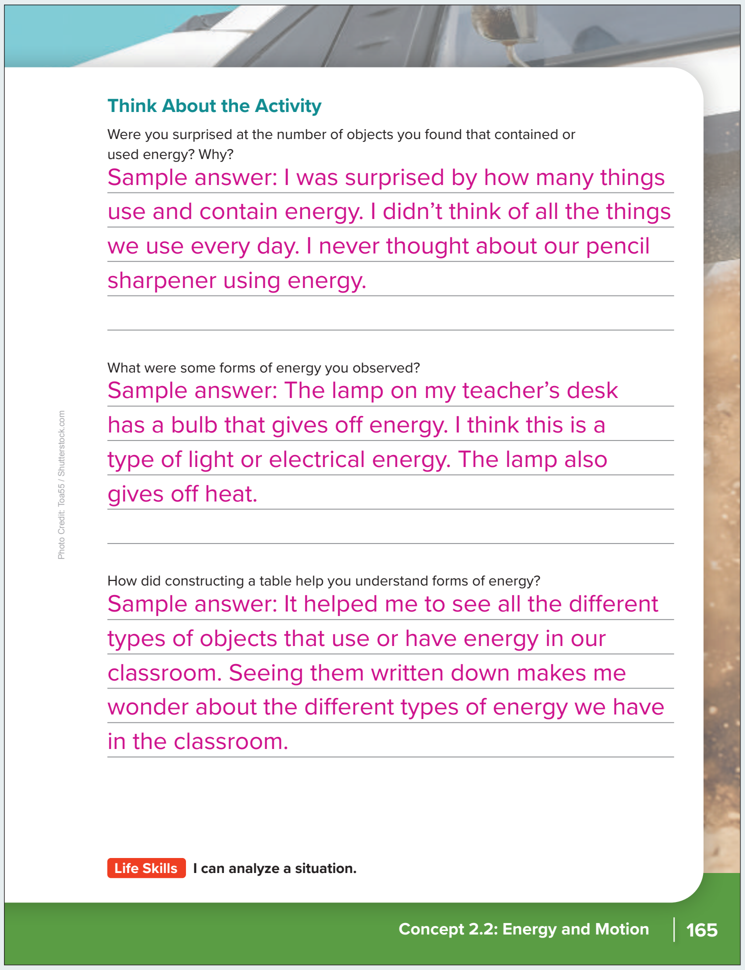

Think About the Activity

Were you surprised at the number of objects you found that contained or used energy? Why?

Sample answer: I was surprised by how many things use and contain energy. I didn't think of all the things we use every day. I never thought about our pencil sharpener using energy.

What were some forms of energy you observed?

Sample answer: The lamp on my teacher's desk has a bulb that gives off energy. I think this is a type of light or electrical energy. The lamp also gives off heat.

How did constructing a table help you understand forms of energy?

Sample answer: It helped me to see all the different types of objects that use or have energy in our classroom. Seeing them written down makes me wonder about the different types of energy we have in the classroom.

Life Skills I can analyze a situation.

Photo Credit: Toa55 / Shutterstock.com

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Lesson 1, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *Were you surprised at the number of objects you found that contained or used energy? Why?*
  Sample answer: I was surprised by how many things use and contain energy. I didn't think of all the things we use every day. I never thought about our pencil sharpener using energy.
- *What were some forms of energy you observed?*
  Sample answer: The lamp on the teacher's desk has a bulb that gives off energy. I think this is a type of light or electrical energy. The lamp also gives off heat.
- *How did constructing a table help you understand forms of energy?*
  Sample answer: It helped me to see all the different types of objects that use or have energy in our classroom. Seeing them written down makes me wonder about the different types of energy we have in the classroom.

Lesson 2

Activate Prior Knowledge

Activity 4
Evaluate Like a Scientist

15 min

What Do You Already Know About Energy and Motion?

Purpose

This formative assessment allows students to demonstrate what they already know about energy and motion. At this point, fully formed scientific answers are less important than students' ability to provide examples to support their reasoning.

Instructional Focus

In this activity, students construct a definition of *energy*, using an example from their daily lives as evidence to support their explanation. Students then consider images of an object in motion to explore the relationship between motion and energy.

Life Skills **Endurance**

Defining Energy

Strategy

The assessment question Defining Energy provides a formative assessment of students' ability to define the term *energy*.

- Remind students that they do not need to know the correct answer at this point and they should simply share ideas.

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2.2 | Wonder How do moving objects get energy?

Activity 4
Evaluate Like a Scientist

What Do You Already Know About Energy and Motion?

Quick Code: egs4105

Defining Energy

You have been thinking a lot about energy. Using what you already know, **write** your own definition of *energy*. Include an example to support your answer.

Student answers will vary. Energy is something that makes things move or change. I eat food for energy, and it helps me grow and move.

Moving Energy

Observe the pictures below and **think** about whether the ball has energy in each picture. **Circle** the images where you think the ball has energy.

Student answers will vary.

Life Skills I can share ideas I am not yet sure about.

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DIGITAL

Activity 4
Evaluate Like a Scientist
What Do You Already Know About Energy and Motion?

Quick Code:
egst4105

- Have students share definitions after responding to the item.
- Remind students that they can add to these definitions or make changes after learning more in the lesson.

Moving Energy

Strategy

The formative assessment question demonstrates students' knowledge of the relationship between energy and motion and will help determine if they are already familiar with "stored" or potential energy. After the assessment, have students explain their reasoning, but do not correct misconceptions until Learn.

Teacher Reflection

Based on my data:

- What content do my students already know?
- What misconceptions do my students have at this point in the course?
- Are any of my students ready for extension at this point in the lesson?

Lesson 2, *continued*

What Is Energy?

Activity 5
Observe Like a Scientist

15 min

Energy Basics

Purpose

This activity builds on student understanding of energy by defining *energy* and connecting the two scientific terms *energy* and *work*. Basic knowledge of these terms prepares students for understanding different forms of energy and how energy is conserved and transferred.

Instructional Focus

In this activity, students watch a video and read a text to obtain evidence to construct an explanation and support their position about visible and invisible forms of energy and the relationship between energy and work.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Prepare students for reading the text and watching the video by asking the following:

ASK

- *Can you see energy?*
- *How do you know if something is using energy?*

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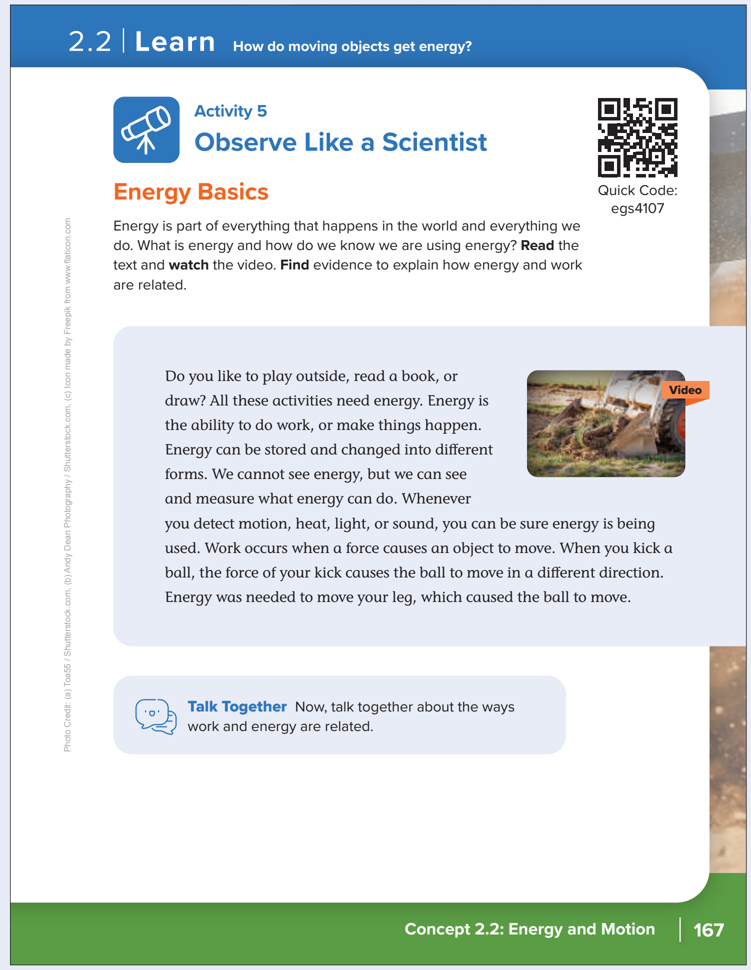

2.2 | Learn How do moving objects get energy?

Activity 5

Observe Like a Scientist

Quick Code: egs4107

Energy Basics

Energy is part of everything that happens in the world and everything we do. What is energy and how do we know we are using energy? **Read** the text and **watch** the video. **Find** evidence to explain how energy and work are related.

Do you like to play outside, read a book, or draw? All these activities need energy. Energy is the ability to do work, or make things happen. Energy can be stored and changed into different forms. We cannot see energy, but we can see and measure what energy can do. Whenever you detect motion, heat, light, or sound, you can be sure energy is being used. Work occurs when a force causes an object to move. When you kick a ball, the force of your kick causes the ball to move in a different direction. Energy was needed to move your leg, which caused the ball to move.

Video

Talk Together Now, talk together about the ways work and energy are related.

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DIGITAL

Activity 5
Observe Like a Scientist
Energy Basics

Quick Code:
egst4107

Photo Credit: Andy Dean Photography / Shutterstock.com

Read the text and watch the video *Energy Basics*, if available.

After reading the text and watching the video, push a chair several meters across the room. Ask students to conclude whether work was performed on the chair. Prompt students to identify the source of the energy used to push the chair.

Ask students to share responses to the ASK questions and encourage them to discuss in pairs or small groups the relationship between energy and work. As students discuss, circulate among them, listening for questions and disagreements to share with the class.

Differentiation

APPROACHING LEARNERS

If students are struggling to understand the different types of energy, have them complete the activity Energy in the Classroom a second time. Incorporate the following changes:

1. Have students look over the table they filled out originally and discuss the forms of energy in those objects.
2. Ask students how they knew these objects have energy.
3. Add some new objects to the classroom, a mix of ones with and without energy, for students to consider.
4. Have students answer the questions from the Think About the Activity section for these new objects.

ADVANCED LEARNERS

Provide students with magazines that can be cut up. Challenge students to find and cut out images of examples that represent different forms of energy.

1. Encourage students to find something for each category on the table.
2. Ask students if there are images that do not fit into any of the categories on the table.

Lesson 2, *continued*

Activity 6
Analyze Like a Scientist

15 min

Kinetic and Potential Energy

Purpose

After considering how objects move in the previous concept, students now take a closer look at how objects get the energy to move. Potential energy may be a new idea for students and is essential for understanding the conservation and transfer of energy.

Instructional Focus

In this activity, students analyze a text about potential energy and kinetic energy and then apply the information to interpret visual data about different acrobats to determine which one has the most potential energy.

Life Skills **Critical Thinking**

Strategy

Prior to reading the text, ask students to talk to a partner about what is happening in the picture of the acrobats. Can they predict what would happen next?

Next, instruct students to read the text about kinetic and potential energy.

With their partner, students will decide which acrobat shown has the most potential energy.

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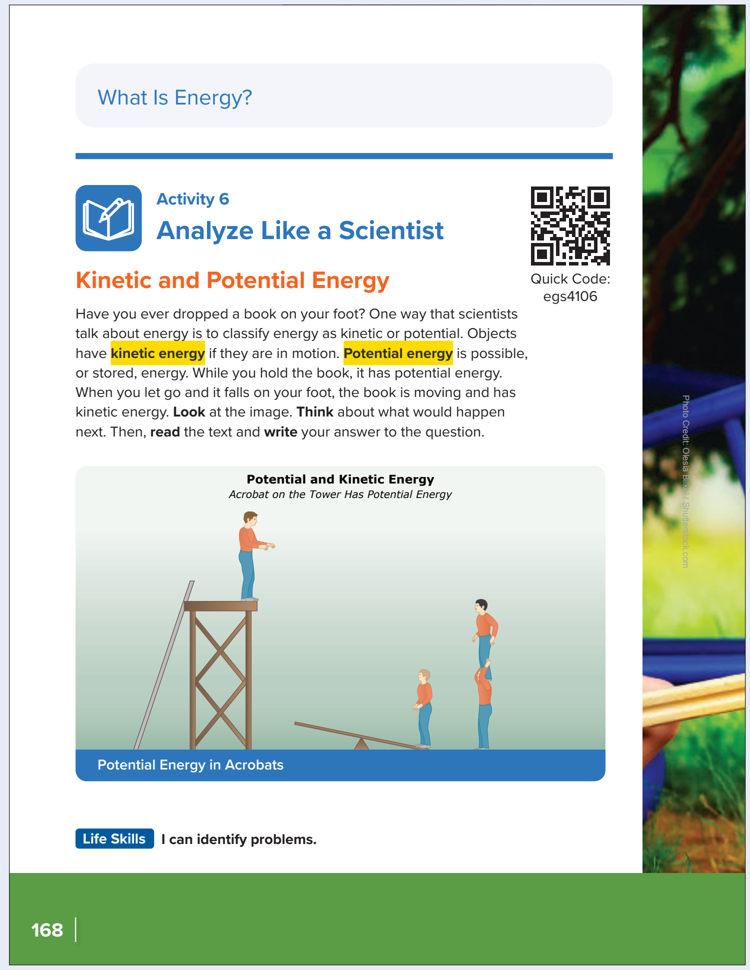
What Is Energy?

Activity 6
Analyze Like a Scientist

Kinetic and Potential Energy

Quick Code: egs4106

Have you ever dropped a book on your foot? One way that scientists talk about energy is to classify energy as kinetic or potential. Objects have **kinetic energy** if they are in motion. **Potential energy** is possible, or stored, energy. While you hold the book, it has potential energy. When you let go and it falls on your foot, the book is moving and has kinetic energy. **Look** at the image. **Think** about what would happen next. Then, **read** the text and **write** your answer to the question.

Potential and Kinetic Energy
Acrobat on the Tower Has Potential Energy

Potential Energy in Acrobats

Life Skills I can identify problems.

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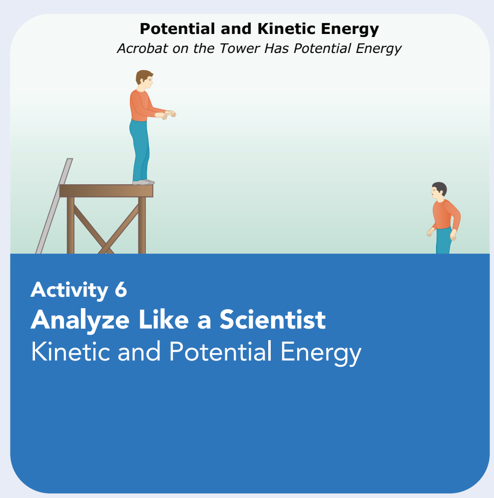
DIGITAL



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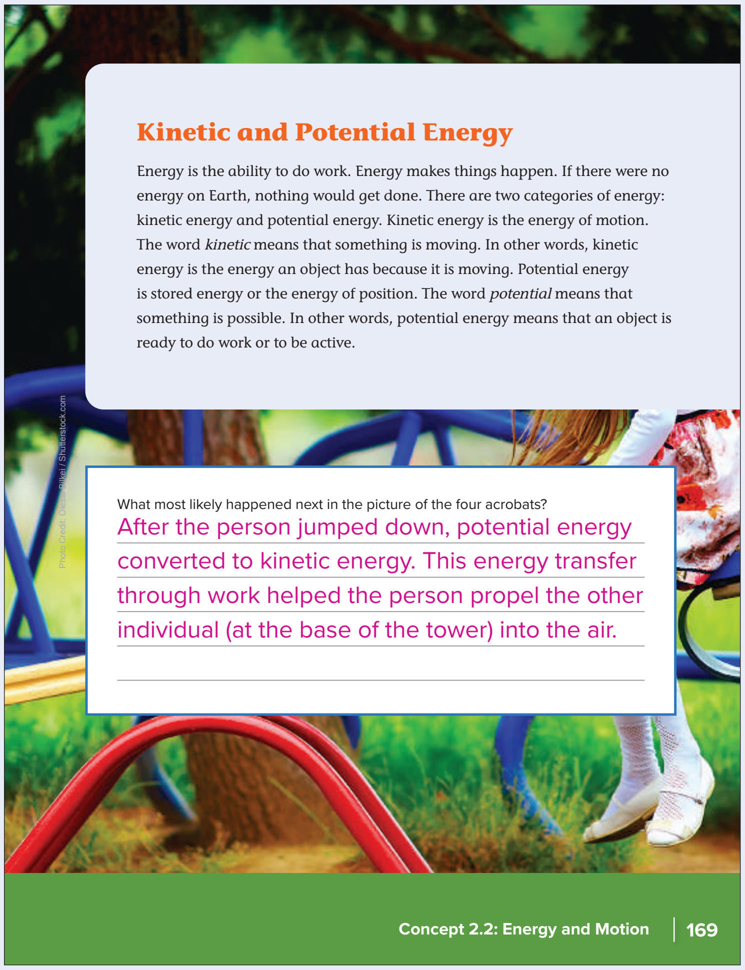

Kinetic and Potential Energy

Energy is the ability to do work. Energy makes things happen. If there were no energy on Earth, nothing would get done. There are two categories of energy: kinetic energy and potential energy. Kinetic energy is the energy of motion. The word *kinetic* means that something is moving. In other words, kinetic energy is the energy an object has because it is moving. Potential energy is stored energy or the energy of position. The word *potential* means that something is possible. In other words, potential energy means that an object is ready to do work or to be active.

What most likely happened next in the picture of the four acrobats?

After the person jumped down, potential energy converted to kinetic energy. This energy transfer through work helped the person propel the other individual (at the base of the tower) into the air.

Lesson 2, *continued*

ASK *What type of energy does the acrobat have when he jumps off the platform?*

The acrobat initially has potential energy. When he jumps off, the potential energy is changed to kinetic energy as he falls.

Lesson 3

What Are the Different Forms of Potential and Kinetic Energy?

Activity 7
Analyze Like a Scientist

25 min

Forms of Potential and Kinetic Energy

Purpose

This activity categorizes different forms of potential and kinetic energy using real-world examples and introduces the idea that energy can change from one form to another.

Instructional Focus

In this activity, students read a text about the forms of potential and kinetic energy and compare the obtained information with their previous knowledge.

Strategy

Before reading, encourage students to use prior knowledge to list as many forms of potential and kinetic energy as they can. Then, instruct students read the text describing the different forms of potential and kinetic energy. After reading, have students revise their list.

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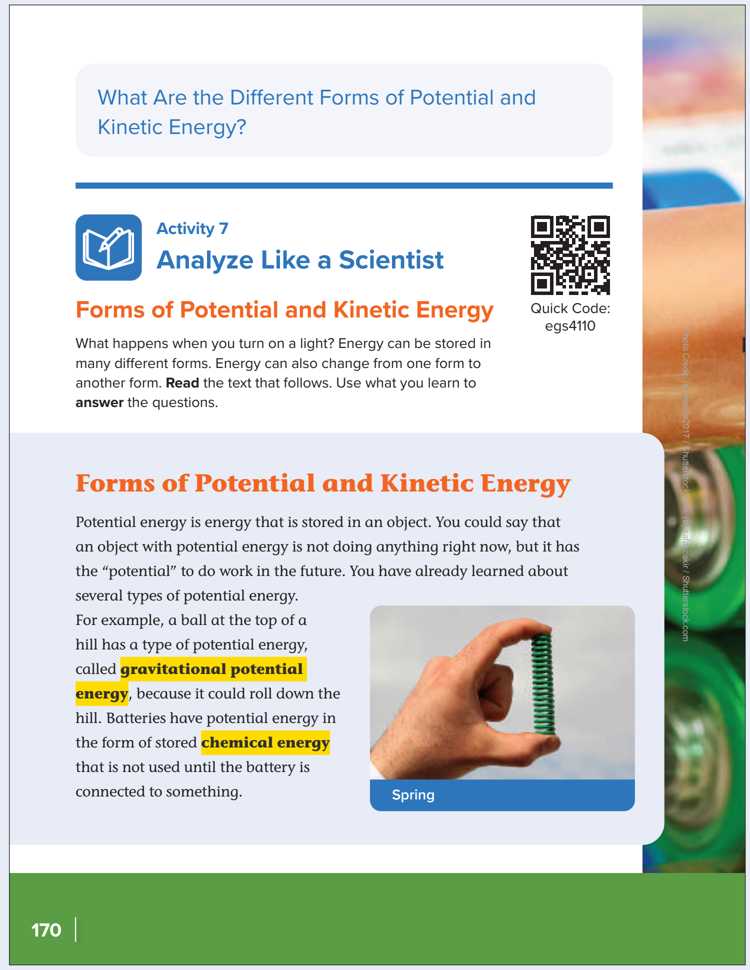

What Are the Different Forms of Potential and Kinetic Energy?

Activity 7

Analyze Like a Scientist

Forms of Potential and Kinetic Energy

Quick Code: egs4110

What happens when you turn on a light? Energy can be stored in many different forms. Energy can also change from one form to another form. **Read** the text that follows. Use what you learn to **answer** the questions.

Forms of Potential and Kinetic Energy

Potential energy is energy that is stored in an object. You could say that an object with potential energy is not doing anything right now, but it has the "potential" to do work in the future. You have already learned about several types of potential energy.

For example, a ball at the top of a hill has a type of potential energy, called **gravitational potential energy**, because it could roll down the hill. Batteries have potential energy in the form of stored **chemical energy** that is not used until the battery is connected to something.

Spring

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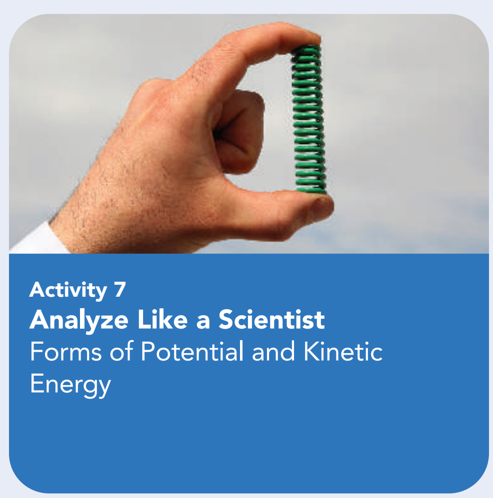

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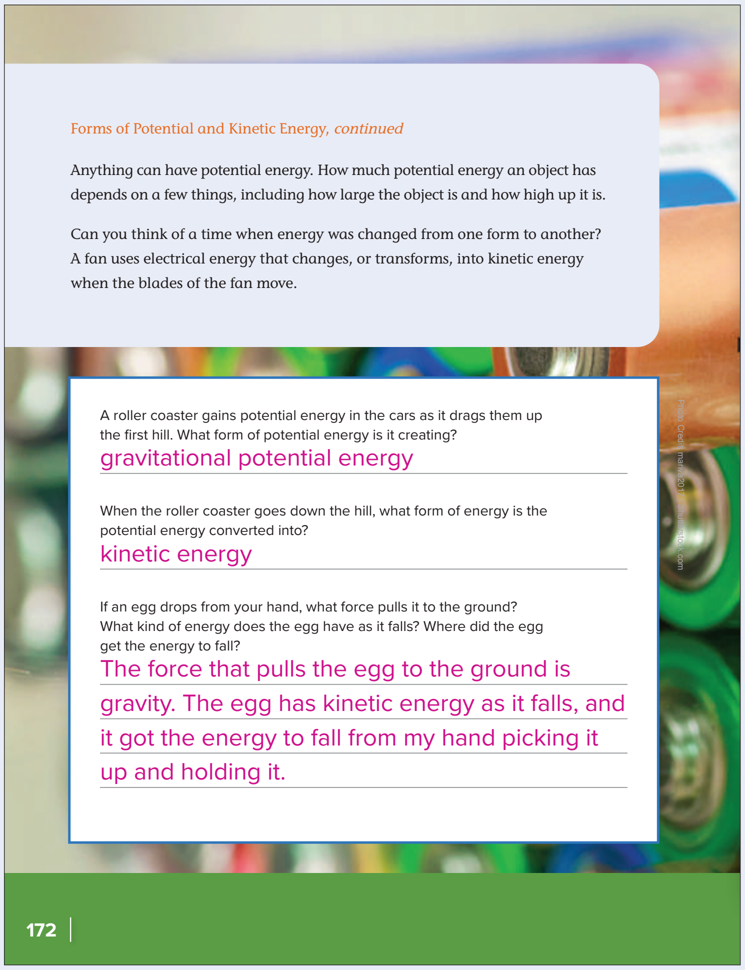

Forms of Potential and Kinetic Energy, *continued*

Anything can have potential energy. How much potential energy an object has depends on a few things, including how large the object is and how high up it is.

Can you think of a time when energy was changed from one form to another? A fan uses electrical energy that changes, or transforms, into kinetic energy when the blades of the fan move.

A roller coaster gains potential energy in the cars as it drags them up the first hill. What form of potential energy is it creating?

gravitational potential energy

When the roller coaster goes down the hill, what form of energy is the potential energy converted into?

kinetic energy

If an egg drops from your hand, what force pulls it to the ground? What kind of energy does the egg have as it falls? Where did the egg get the energy to fall?

The force that pulls the egg to the ground is gravity. The egg has kinetic energy as it falls, and it got the energy to fall from my hand picking it up and holding it.

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Lesson 3, *continued*

ASK

- *A roller coaster will convert stored potential energy in the cars as it drags them up the first hill. What form of potential energy is it creating?* *gravitational potential energy*
- *When the roller coaster goes down the hill, what form of energy is it converted into?* *As the roller coast rises in height, it gains potential energy. This is converted into kinetic energy as it goes down the hill. Since energy cannot be created or destroyed, the roller coaster will not "run out" of energy. When the roller coaster stops, all of its kinetic energy has been transformed to other types of energy.*
- *If a raw egg drops from your hand, what force pulls it to the ground? What kind of energy does the egg have as it falls? Where did the egg get the energy to fall?* *The force that pulls the egg to the ground is gravity. The egg has kinetic energy as it falls, and it got the energy to fall from my hand picking it up and holding it.*

Lesson 3, *continued*

Activity 8
Observe Like a Scientist

20 min

Types of Energy

Purpose
Students explore real-world examples to better understand the transformation of energy from potential to kinetic or vice versa.

Instructional Focus
In this activity, students apply the information about the different forms of potential energy obtained in the previous activity to interpret the text and video *Types of Energy* and discuss how energy changes form.

Strategy
Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Before watching the video, review kinetic and potential energy by instructing students to rub their hands together. Ask students to identify the motion as either kinetic or potential energy. *(Kinetic)*. Then ask students to explain how they could increase the kinetic energy.

Ask students to identify the source of the potential energy in the hand rubbing activity.

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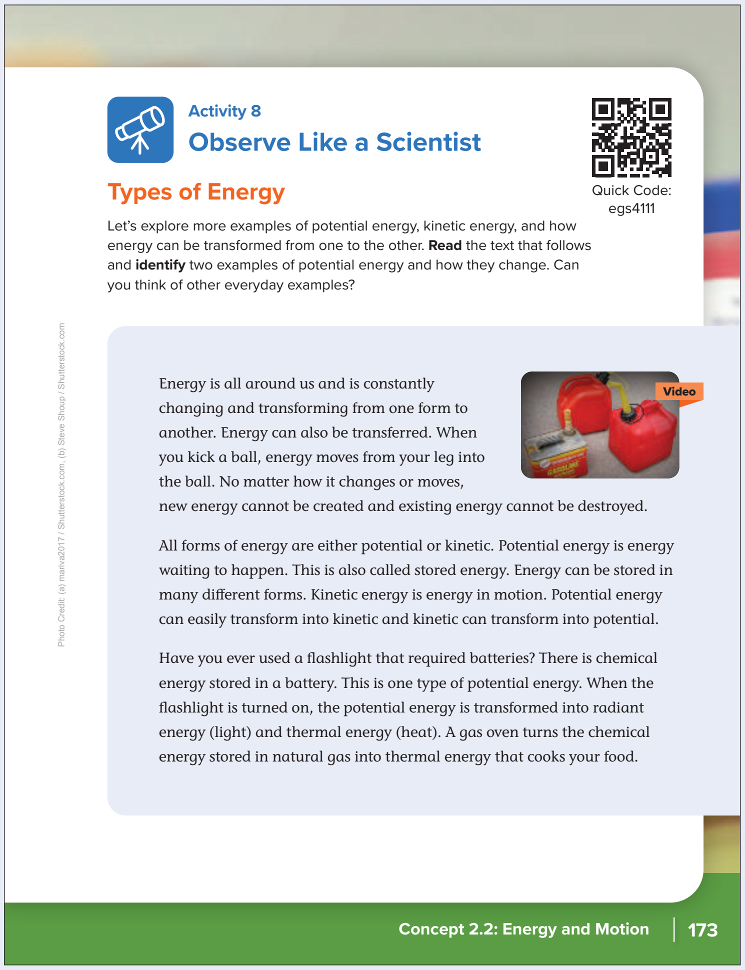
Activity 8
Observe Like a Scientist

Types of Energy

Quick Code: egs4111

Let's explore more examples of potential energy, kinetic energy, and how energy can be transformed from one to the other. **Read** the text that follows and **identify** two examples of potential energy and how they change. Can you think of other everyday examples?

Video

Energy is all around us and is constantly changing and transforming from one form to another. Energy can also be transferred. When you kick a ball, energy moves from your leg into the ball. No matter how it changes or moves, new energy cannot be created and existing energy cannot be destroyed.

All forms of energy are either potential or kinetic. Potential energy is energy waiting to happen. This is also called stored energy. Energy can be stored in many different forms. Kinetic energy is energy in motion. Potential energy can easily transform into kinetic and kinetic can transform into potential.

Have you ever used a flashlight that required batteries? There is chemical energy stored in a battery. This is one type of potential energy. When the flashlight is turned on, the potential energy is transformed into radiant energy (light) and thermal energy (heat). A gas oven turns the chemical energy stored in natural gas into thermal energy that cooks your food.

Photo Credit: (a) mariva2017 / Shutterstock.com, (b) Steve Shoup / Shutterstock.com

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Activity 8
Observe Like a Scientist
Types of Energy

Quick Code:
egst4111

Photo Credit: Steve Shoup / Shutterstock.com

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2.2 | Learn How do moving objects get energy?

The food you eat also stores another type of chemical energy. Your digestive system breaks down the food you eat into energy it can store.

If you have ever used a spring-powered car, you might have noticed that its spring wire stores kinetic energy. When you let go, the spring wire unwinds and transforms into kinetic energy to make the car move. A real car transforms chemical energy into mechanical, sound, and thermal energy that are all kinetic as it drives down the road. The engine is where this transformation takes place, but can you guess what the source of the potential energy is in this example?

Talk Together In pairs, discuss two examples of potential energy being converted into kinetic energy from the passage. Identify the types of energy involved. Then, share a new example of this transformation from your daily life.

Photo Credit: (a) Pixabay, (b) Icon made by Freepik from www.flaticon.com

Optional Digital Activity 9

Observe Like a Scientist

Forms of Energy

Go online to complete this activity.

Quick Code: egs4114

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Lesson 3, *continued*

Prepare students for reading the text and watching the videos by asking the following:

ASK

- *What are two examples of potential energy?*
  A ball on the ground or a book on a table.
- *How can the potential energy change in your examples?*
  If you kick the ball or drop the book, the potential energy becomes kinetic.

Read the text and watch the video *Types of Energy*.

After reading the text and watching the videos, ask students to discuss in pairs how the potential energy changed in various examples. Ask student pairs to share original examples with the class.

As students discuss, circulate among them, listening for questions and disagreements to share with the class.

Optional Digital Activity 9

Observe Like a Scientist

15 min

Forms of Energy

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4114

Lesson 4

Activity 10
Analyze Like a Scientist

20 min

Energy Transformation in Engines

Purpose

Students have become familiar with the ideas of energy in different forms and the transfer of energy. Now, in preparation for the culminating work that they will do in the Unit Project, students explore how all these ideas come together in the practical example of an engine.

Instructional Focus

In this activity, students use the knowledge acquired in previous activities to interpret a text about the energy conversions in an engine and identify which passages represent examples of potential energy.

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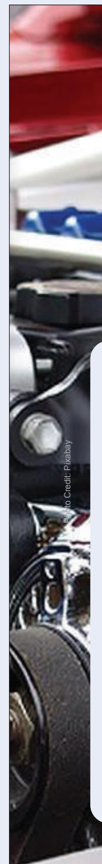

Activity 10
Analyze Like a Scientist

Quick Code: egs4113

Energy Transformation in Engines

You have learned a lot about energy so far. You now know that energy exists in different forms and that energy is constantly changing. Use what you know about potential (stored) energy and kinetic (motion) energy. **Read** the text that follows and **look** for examples of these two types of energy. **Underline** or highlight examples of potential energy and **circle** examples of kinetic energy. Then, **answer** the questions based on your findings.

Energy Transformation in Engines

Car Engine

You might know that cars and trucks need gasoline to run, but what is gasoline made of? How does it make a car move? Gasoline contains chemical energy, and a car's engine transforms that energy to power the car. Gasoline also powers trucks, boats, and many other large and small vehicles.

The energy in gasoline is called chemical potential energy. It is called potential energy because it has the potential to power many things. It is just like the food you eat that gives you energy for your day. The moving car has mechanical kinetic energy. You may have noticed that when a car engine runs, it makes noise and gives off heat. This means that some of the potential energy is being transformed into sound and thermal energy.

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Photo Credit: Pixabay

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Activity 10
Analyze Like a Scientist
Energy Transformations in Engines

Quick Code:
egst4113

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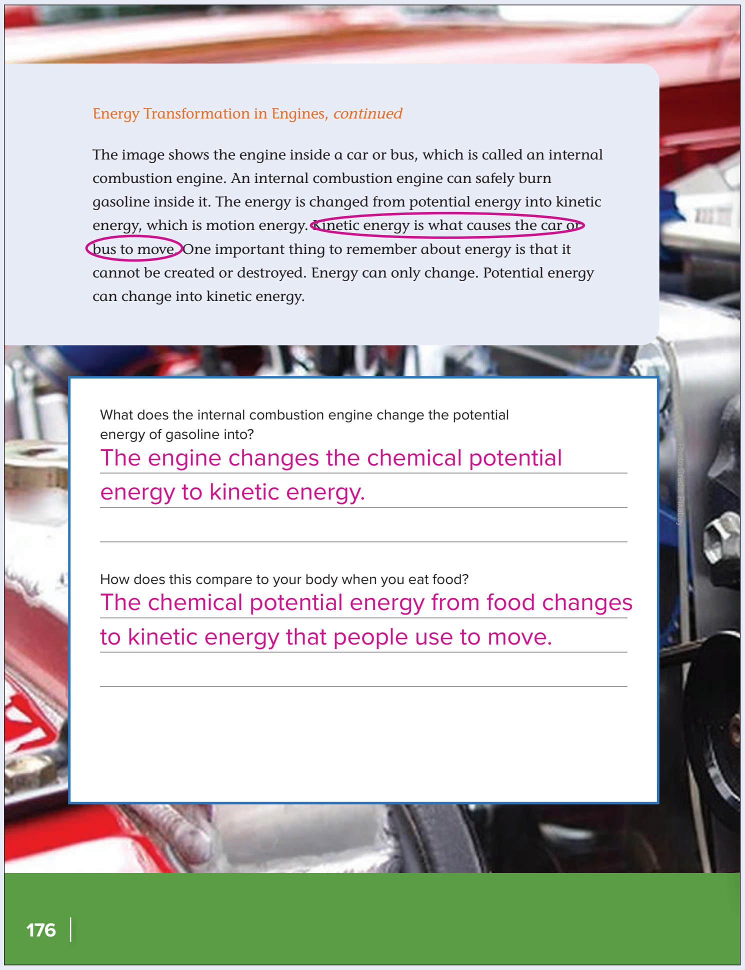

Energy Transformation in Engines, *continued*

The image shows the engine inside a car or bus, which is called an internal combustion engine. An internal combustion engine can safely burn gasoline inside it. The energy is changed from potential energy into kinetic energy, which is motion energy. Kinetic energy is what causes the car or bus to move. One important thing to remember about energy is that it cannot be created or destroyed. Energy can only change. Potential energy can change into kinetic energy.

What does the internal combustion engine change the potential energy of gasoline into?

The engine changes the chemical potential energy to kinetic energy.

How does this compare to your body when you eat food?

The chemical potential energy from food changes to kinetic energy that people use to move.

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Lesson 4, *continued*

Strategy

To reinforce the concepts explored in the previous activities on potential and kinetic energy, have the students read the text describing the energy conversions that take place in an engine.

As students read, have them underline or highlight examples of potential energy. Have them circle examples of kinetic energy.

ASK

- *What does the internal combustion engine change the potential energy of gasoline into?*
  The engine changes the chemical potential energy to kinetic energy.
- *How does this compare to your body when you eat food?*
  The internal combustion engine transforms the chemical energy of gasoline into kinetic energy and heat energy.

Differentiation

ADVANCED LEARNERS

Challenge students to create a diagram of the flow of kinetic and potential energy.

Lesson 4, *continued*

Activity 11
Evaluate Like a Scientist

25 min

Easy Life Tool

Purpose

Students have learned about the different forms of energy: potential and kinetic. They should also be able to identify different types of energy, such as chemical and thermal. By designing a simple machine, students demonstrate their conceptual understanding through a practical application. This activity also serves as a formative assessment of student understanding to this point.

Instructional Focus

In this activity, students share ideas to design a solution for converting a type of energy and making objects move that could simplify their life.

Life Skills **Decision-Making**

Strategy

Consider spending a few minutes having students brainstorm in small groups different sources and forms of potential energy that could be used to make objects move. These will include different fuels—gasoline, diesel, coal—but may also include potential energy stored in batteries, catapults, springs, and more.

Ask students to share their ideas. Students will return to fuels as energy resources in a later unit.

Then, direct students to complete the activity Easy Life Tool.

Differentiation

ADVANCED LEARNERS

In groups, have students discuss the question: *What do you know about energy and motion?* Have students map out what they have learned throughout this section.

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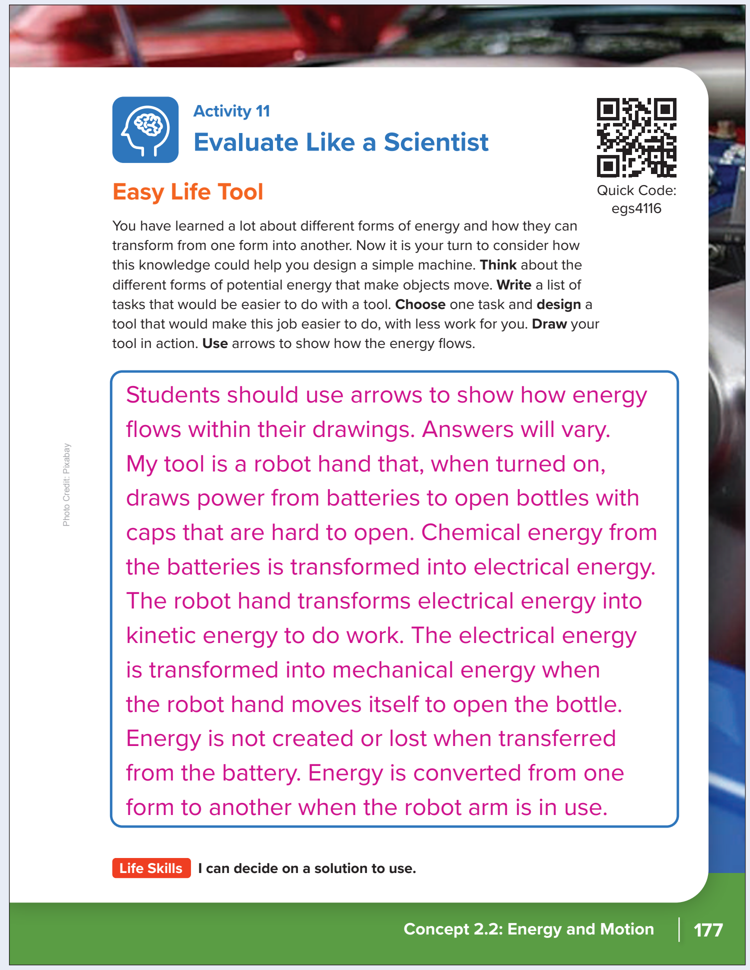
Activity 11
Evaluate Like a Scientist
Easy Life Tool

Quick Code: egs4116

You have learned a lot about different forms of energy and how they can transform from one form into another. Now it is your turn to consider how this knowledge could help you design a simple machine. **Think** about the different forms of potential energy that make objects move. **Write** a list of tasks that would be easier to do with a tool. **Choose** one task and **design** a tool that would make this job easier to do, with less work for you. **Draw** your tool in action. **Use** arrows to show how the energy flows.

Students should use arrows to show how energy flows within their drawings. Answers will vary. My tool is a robot hand that, when turned on, draws power from batteries to open bottles with caps that are hard to open. Chemical energy from the batteries is transformed into electrical energy. The robot hand transforms electrical energy into kinetic energy to do work. The electrical energy is transformed into mechanical energy when the robot hand moves itself to open the bottle. Energy is not created or lost when transferred from the battery. Energy is converted from one form to another when the robot arm is in use.

Life Skills I can decide on a solution to use.

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Activity 11
Evaluate Like a Scientist
Easy Life Tool

Quick Code:
egst4116

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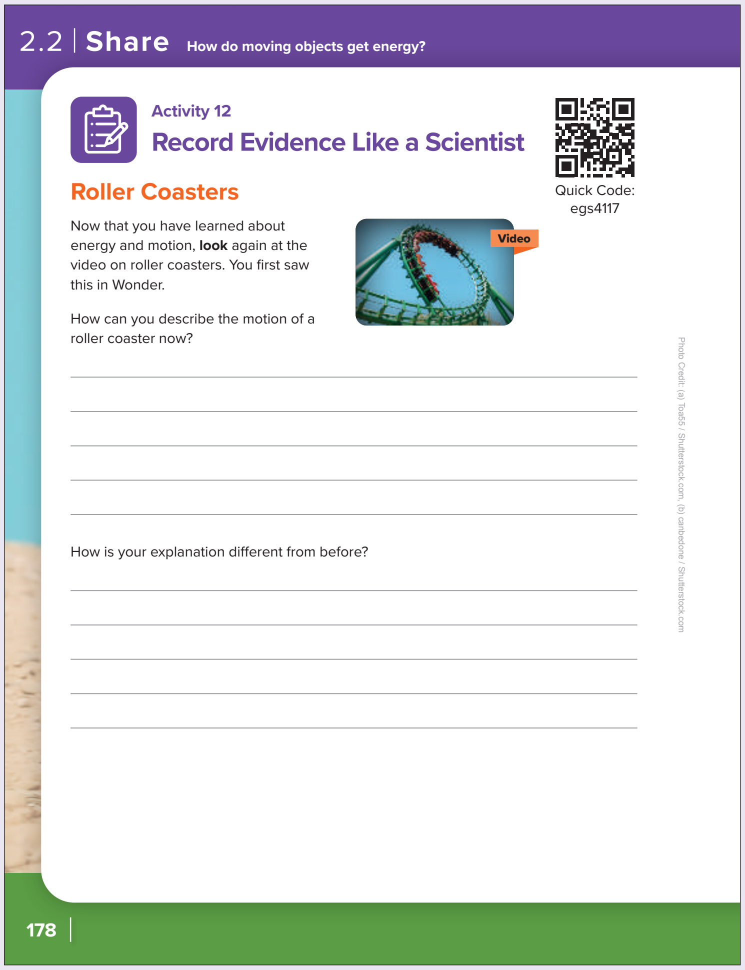
2.2 | Share How do moving objects get energy?

Activity 12
Record Evidence Like a Scientist

Quick Code: egs4117

Roller Coasters

Now that you have learned about energy and motion, **look** again at the video on roller coasters. You first saw this in Wonder.

Video

How can you describe the motion of a roller coaster now?

How is your explanation different from before?

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Photo Credit: canbedone / Shutterstock.com

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Activity 12
Record Evidence Like a Scientist
Roller Coasters

Quick Code:
egst4117

Lesson 5

Scientific Explanation

Activity 12
Record Evidence Like a Scientist

20 min

Roller Coasters

Purpose

Students return to the questions posed at the beginning of the concept and reconsider what they know now about energy and motion. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students review and discuss their initial explanations about the Investigative Phenomenon Roller Coasters based on the information on the types and forms of energy acquired in the previous activities.

Strategy

Display the Investigative Phenomenon of the *Roller Coasters* video and the Can You Explain? question. Ask students to discuss their explanation for the Investigative Phenomenon with a partner or as a whole class.

After allowing students to discuss,

ASK *How can this explanation help you answer the Can You Explain? question?*

Lesson 5, *continued*

After providing scaffolding to the students, for those students able to do so, allow them to construct a full scientific explanation. They can write, draw, or orally describe their claim, evidence, and reasoning.

As students would have already reviewed sample scientific explanations in earlier units, they should be familiar with the claim, reasoning, and evidence framework. You may want to review the following:

A **Claim** is a one-sentence answer to the question you investigated. It answers, *What can you conclude?* It should *not* start with yes or no.

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Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?

How do moving objects get energy?

Now, you will use your new ideas about energy and motion to write a scientific explanation that answers the Can You Explain? question. To plan your scientific explanation, first **write** your claim:

My claim:

Student answers will vary. Objects get kinetic energy when other forms of energy are transformed.

Photo Credit: Toa55 / Shutterstock.com

Concept 2.2: Energy and Motion | 179

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2.2 | **Share** **How do moving objects get energy?**

Next, **identify** two pieces of evidence that support your claim. **Record** your evidence in the first column. Finally, **explain** your reasoning. Reasoning ties together the claim and the evidence. Reasoning shows how or why the data count as evidence to support the claim.

Evidence	Reasoning That Supports Claim
We read about how acrobats, cars, and roller coasters all transform energy. They each turn potential (stored) energy into the energy of motion (kinetic). We also recorded that items in our classroom had different energy sources. Some objects used electricity, while others used batteries.	When a roller coaster is at the top of a hill, it has potential energy. This is transformed into kinetic energy when the roller coaster goes down the hill. Batteries have potential energy stored in them. This is transformed into kinetic energy when they make objects, like a battery-powered fan, move.

Photo Credit: Toa55 / Shutterstock.com

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Lesson 5, *continued*

Evidence must be:

- Sufficient—use enough evidence to support the claim.
- Appropriate—use data that support your claim. Leave out information that doesn't support the claim.

Reasoning ties together the claim and the evidence.

- It shows how or why the data count as evidence to support the claim.
- It provides the justification for why this evidence is important to this claim.
- It includes one or more scientific principles that are important to the claim and evidence.

Lesson 5, *continued*

Have students generate a scientific explanation to answer the Can You Explain? question.

Can You Explain?

How do moving objects get energy?

Sample student response:
All moving objects have energy. Kinetic energy is energy of motion. Objects get kinetic energy when they move. For example, a ball at the top of a hill that is not moving has no kinetic energy. The ball has only potential energy from the pull of gravity. As it begins to move down the hill, the potential energy is converted to kinetic energy. This is similar to a roller coaster. When the roller coaster is at the top of the hill, it has the most potential energy, and as it moves down the track, the potential energy is converted to kinetic energy. When the ball comes to rest at the bottom of the hill, there is no more kinetic energy in the ball. Energy comes in different forms. For example, natural gas is stored chemical energy. When it is burned, it will convert the energy to heat energy, which will move a hot-air balloon, converting it to kinetic energy.

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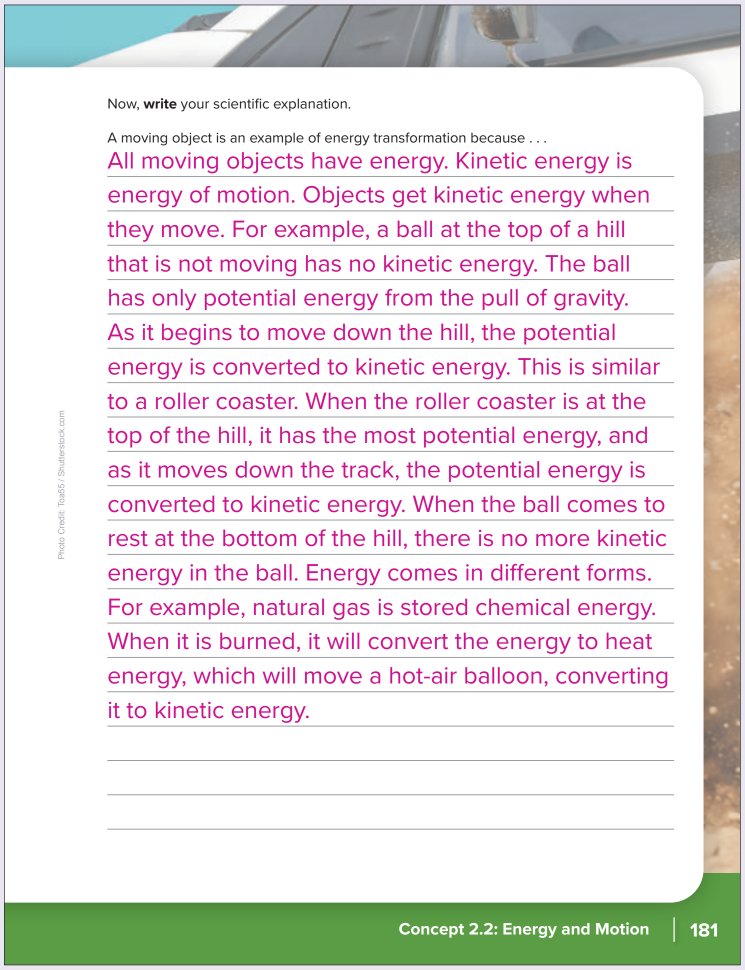

Now, **write** your scientific explanation.

A moving object is an example of energy transformation because . . .

All moving objects have energy. Kinetic energy is energy of motion. Objects get kinetic energy when they move. For example, a ball at the top of a hill that is not moving has no kinetic energy. The ball has only potential energy from the pull of gravity. As it begins to move down the hill, the potential energy is converted to kinetic energy. This is similar to a roller coaster. When the roller coaster is at the top of the hill, it has the most potential energy, and as it moves down the track, the potential energy is converted to kinetic energy. When the ball comes to rest at the bottom of the hill, there is no more kinetic energy in the ball. Energy comes in different forms. For example, natural gas is stored chemical energy. When it is burned, it will convert the energy to heat energy, which will move a hot-air balloon, converting it to kinetic energy.

Concept 2.2: Energy and Motion | 181

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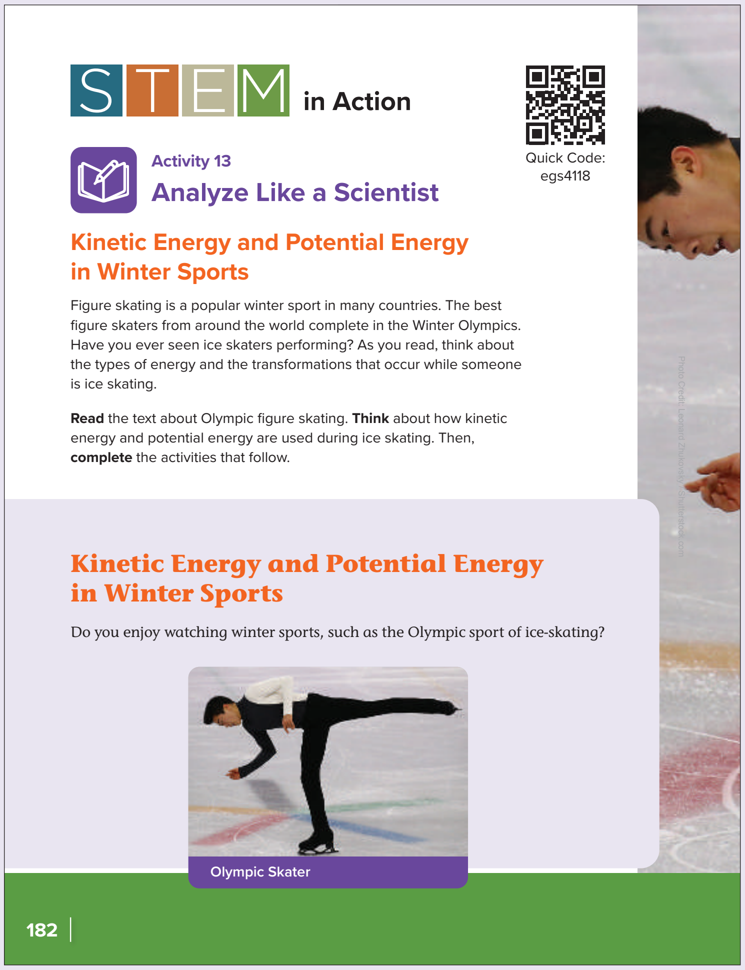

STEM in Action

Quick Code: egs4118

Activity 13

Analyze Like a Scientist

Kinetic Energy and Potential Energy in Winter Sports

Figure skating is a popular winter sport in many countries. The best figure skaters from around the world complete in the Winter Olympics. Have you ever seen ice skaters performing? As you read, think about the types of energy and the transformations that occur while someone is ice skating.

Read the text about Olympic figure skating. **Think** about how kinetic energy and potential energy are used during ice skating. Then, **complete** the activities that follow.

Kinetic Energy and Potential Energy in Winter Sports

Do you enjoy watching winter sports, such as the Olympic sport of ice-skating?

Olympic Skater

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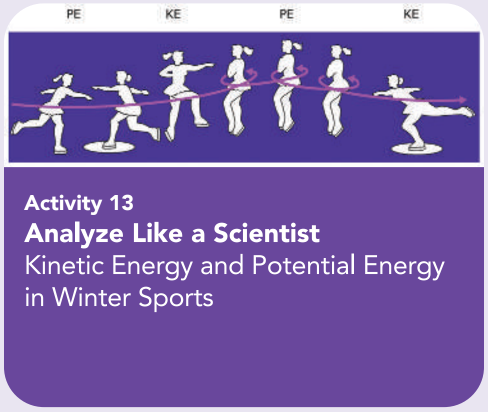
DIGITAL



Quick Code: egst4118

STEM in Action

Activity 13

Analyze Like a Scientist

10 min

Kinetic Energy and Potential Energy in Winter Sports

Purpose

Students consider the real-world scenario of figure skating and determine when the most and least amounts of kinetic and potential energy are used. This activity provides students the opportunity to apply what they know about energy and motion to an Olympic sport.

Instructional Focus

In this activity, students construct an explanation to compare the kinetic and potential energy involved in figure skating.

Strategy

Applying knowledge to new and sometimes unfamiliar situations helps students build mental flexibility, creative thinking, and curiosity. If students are unfamiliar with figure skating or other winter sports, encourage them to imagine what the experience might be like before reading the text. In class discussion, encourage students to make connections between what they read and their own favorite sports.

Instruct students to read the text and view the images in the passage. If possible, project the Ice-Skating Jump image on a large screen. Also have the students view the image Ice-Skating Jump and the image Nathan Chen, both online.

- Show each image on a large screen. If possible, cover the letters above the Ice-Skating Jump image until after students discuss the questions. As a class, determine where the skater has the most kinetic energy and the most potential energy.

Lesson 5, *continued*

- Next, have students determine where the skater has the least kinetic and potential energy.
- In the image Ice-Skating Jump, the skater has the most kinetic energy when her feet leave the ice, between the second and third images. She has the most potential energy in the fourth image, at the top of her jump. If students have trouble with the activity, have them review the images again.

More Potential Energy or More Kinetic Energy?

Strategy

After reading the text and viewing the images, the students should attempt the formative assessment More Potential Energy or More Kinetic Energy? Which pictures show more potential energy, and which ones show more kinetic energy? Students should circle the pictures that show more potential energy.

ENTREPRENEURSHIP

Entrepreneurs use the resources of self-awareness, self-evaluation, motivation, and perseverance. When reading about these Olympic athletes, ask students how they think that athletes set ambitious goals and stay motivated. What obstacles might an Olympic athlete face when trying to achieve his or her vision? As entrepreneurs, students will need to draw upon the resources of self-awareness and self-evaluation as they set personal goals and work toward their collective or individual vision.

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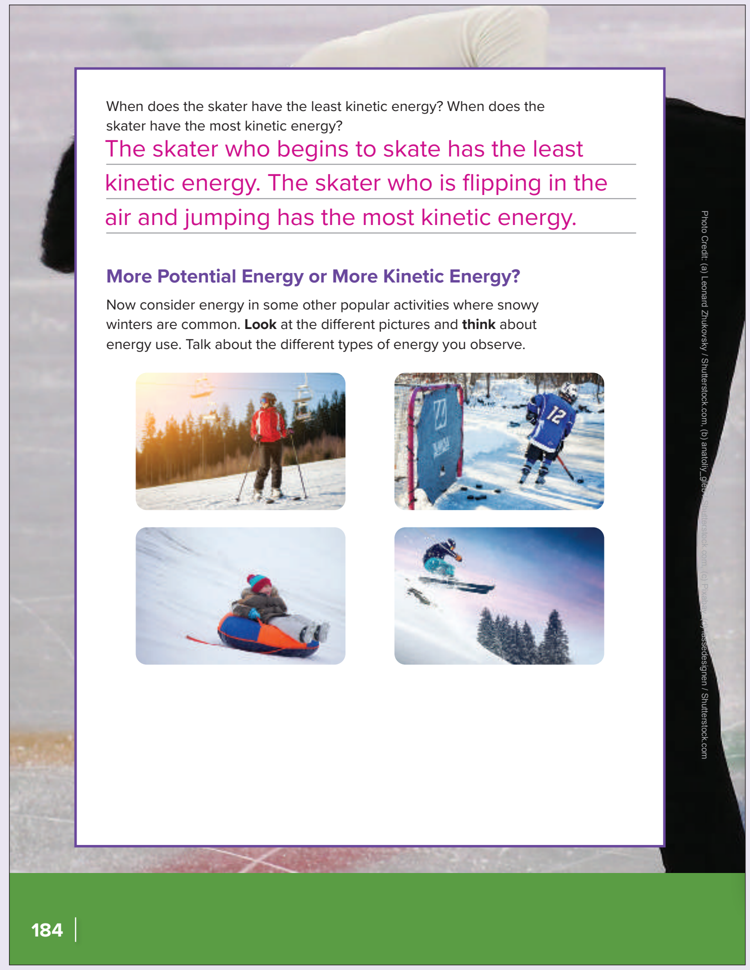

When does the skater have the least kinetic energy? When does the skater have the most kinetic energy?

The skater who begins to skate has the least kinetic energy. The skater who is flipping in the air and jumping has the most kinetic energy.

More Potential Energy or More Kinetic Energy?

Now consider energy in some other popular activities where snowy winters are common. **Look** at the different pictures and **think** about energy use. Talk about the different types of energy you observe.

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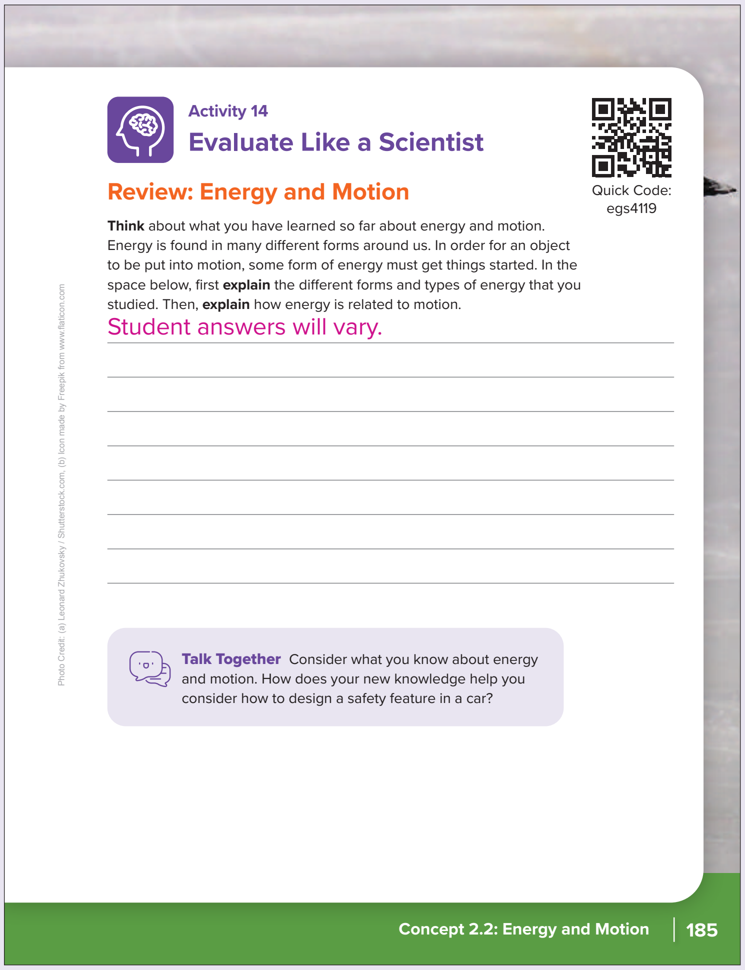

Activity 14
Evaluate Like a Scientist

Quick Code: egs4119

Review: Energy and Motion

Think about what you have learned so far about energy and motion. Energy is found in many different forms around us. In order for an object to be put into motion, some form of energy must get things started. In the space below, first **explain** the different forms and types of energy that you studied. Then, **explain** how energy is related to motion.

Student answers will vary.

Talk Together Consider what you know about energy and motion. How does your new knowledge help you consider how to design a safety feature in a car?

Concept 2.2: Energy and Motion | 185

DIGITAL

Activity 14
Evaluate Like a Scientist
Review: Energy and Motion

Quick Code:
egst4119

Lesson 5, *continued*

Review and Assess

Activity 14
Evaluate Like a Scientist

15 min

Review: Energy and Motion

Purpose

The final activity of the concept asks students to review and explain the main ideas of energy and motion, and then connect their understanding to the unit theme.

Instructional Focus

In this activity, students communicate what they have learned about energy and motion in writing.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas. You may also assign students the summative assessment for this concept.

In the summative concept assessment, students will determine how we use different types of energy and what the difference is between kinetic and potential energy.

Teacher Reflection

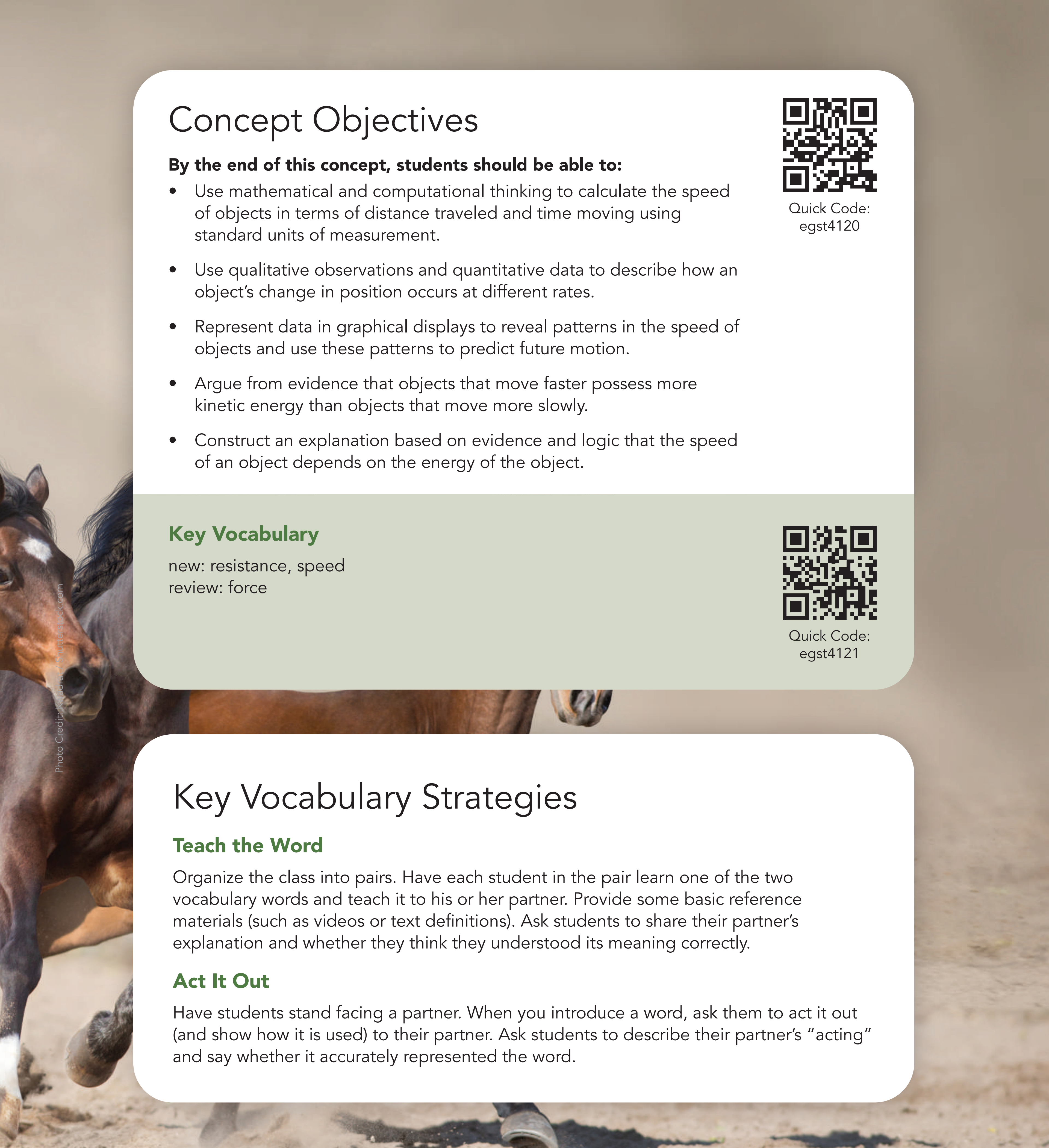
- How many of my students met the objectives for this concept?
- For students who did not meet the objectives, what are my next steps?

CONCEPT

2.3

Speed

Photo Credit: Kwadrat / Shutterstock.com



Concept Objectives

By the end of this concept, students should be able to:

- Use mathematical and computational thinking to calculate the speed of objects in terms of distance traveled and time moving using standard units of measurement.
- Use qualitative observations and quantitative data to describe how an object's change in position occurs at different rates.
- Represent data in graphical displays to reveal patterns in the speed of objects and use these patterns to predict future motion.
- Argue from evidence that objects that move faster possess more kinetic energy than objects that move more slowly.
- Construct an explanation based on evidence and logic that the speed of an object depends on the energy of the object.

Quick Code:
egst4120

Key Vocabulary

new: resistance, speed
review: force

Quick Code:
egst4121

Key Vocabulary Strategies

Teach the Word

Organize the class into pairs. Have each student in the pair learn one of the two vocabulary words and teach it to his or her partner. Provide some basic reference materials (such as videos or text definitions). Ask students to share their partner's explanation and whether they think they understood its meaning correctly.

Act It Out

Have students stand facing a partner. When you introduce a word, ask them to act it out (and show how it is used) to their partner. Ask students to describe their partner's "acting" and say whether it accurately represented the word.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	20 min
		Activity 3	15 min
Learn	Lesson 2	Activity 4	25 min
		Activity 5	20 min
	Lesson 3	Activity 6	45 min
	Lesson 4	Activity 7	10 min
		Activity 8	35 min
	Lesson 5	Activity 9	15 min
		Activity 11	10 min
Share		Activity 12	20 min
	Lesson 6	Activity 13	25 min
		Activity 14	20 min

Content Background

Speed

An understanding of energy, motion, and work helps prepare students for using these concepts as variables in investigations. To make sense of the data that they will gather in these experiments, students must first understand speed as a scientific concept. Students must also be able to make calculations to quantify speed.

Speed is defined as the rate at which an object moves over a distance. When we describe speed, we use numbers. For example, we talk about cars moving 40 kilometers per hour. As an object moves, its position is always changing. Furthermore, some type of force is required to change an object's speed. The amount of force needed to change an object's motion depends largely on the object's mass, with larger objects requiring more force to slow, stop, or change direction. For example, the amount of force needed to get a large truck moving is much greater than the amount of force needed to move a small car. Once in motion, the large truck requires a much greater counterforce than the car to slow down or stop.

Calculating and Comparing Speeds

Words such as *faster* and *slower* help us compare the speeds of moving objects. Speed is calculated by taking the distance that an object travels and dividing that by the travel time. The mathematical formula for speed can be worded as "speed equals the distance traveled over time." For this reason, the units of speed relate distance to time. Examples of speed measurements include 5 kilometers per hour, or km/hr (typical walking speed), 13 centimeters per year (typical speed for growing fingernails), and 51 centimeters per minute (typical speed for an earthworm). Speed, distance, and time are related to one another. If two of the three quantities are known, then the third can be calculated.

To help students understand this idea, talk through scenarios where two friends are running together. You may consider discussing various situations such as the following. In a race, one friend may sprint for a time, while the other maintains a steady pace. If both students run the same distance, the top speed of each runner is not important. At the end of the race, the runner who ran the distance in less total time had the fastest speed. On the other hand, if two friends run a race with the same elapsed time but one friend ran a farther distance, the runner who ran a longer distance completed the race at a faster speed.

Throughout Concept 3, students will gain a practical knowledge of both speed and how it relates to the other physical phenomena they have explored. As they proceed into Concept 4, students apply these ideas to practical real-world scenarios by exploring collisions.

Hands-On Investigations Preparation

Learn

Location	Instructional Focus	Materials to Prepare (per group)
Activity 6: Measuring Speed	In this activity, students will work in groups to measure the speed of various balls traveling down a ramp.	• 30-centimeter ramp • 3 balls, such as tennis balls, golf balls, marbles, or table-tennis balls • Meterstick or measuring tape • Masking tape • Books • Stopwatch • Balance (optional)
Activity 8: Racing Downhill	In this activity, students will use model trucks to measure the speed and kinetic energy of objects moving down inclines of various angles.	• Toy trucks • Cardboard paper towel tube • Paper cup, 360 mL • Scissors • Several books • Metric ruler • Removable sticky note flags • Stopwatch

Lesson 1

Activity 1
Can You Explain?

10 min

How can you measure the speed of something moving fast?

Purpose

This activity builds on the concepts of energy and motion by asking students to consider how to measure the speed of an object. During this concept, students will be connecting speed with what they already know about energy and motion to promote critical thinking about vehicle safety features.

Instructional Focus

In this activity, students begin to think about how they could measure the speed of a moving train.

Life Skills **Endurance**

Strategy

Students may have some initial ideas about how to answer the question (see sample student response in the Student Materials page). By the end of the concept, students should be able to construct a scientific explanation, which includes evidence from the concept activities.

Differentiation

APPROACHING LEARNERS

For students with very little or no prior experience with an understanding of the nature of speed as it relates to distance, the Wonder activities and Can You Explain? question will be difficult to answer. Schedule time before or after class to explain and show why these factors are related to each other. Visual illustrations such as diagrams may be useful when explaining this relationship.

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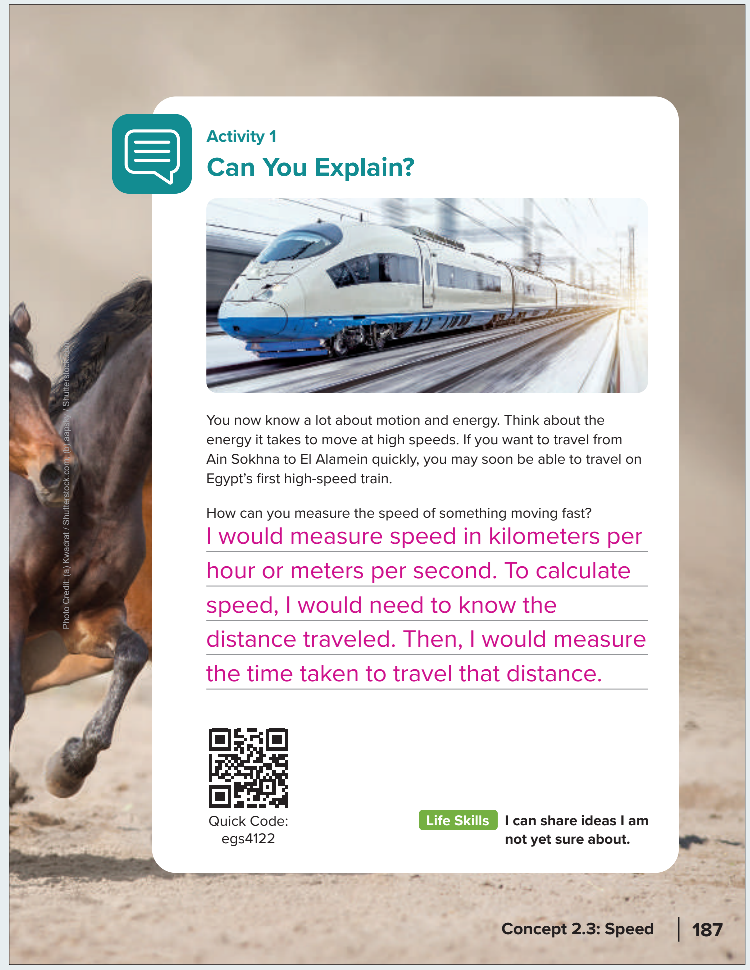
Activity 1
Can You Explain?

You now know a lot about motion and energy. Think about the energy it takes to move at high speeds. If you want to travel from Ain Sokhna to El Alamein quickly, you may soon be able to travel on Egypt's first high-speed train.

How can you measure the speed of something moving fast?

I would measure speed in kilometers per hour or meters per second. To calculate speed, I would need to know the distance traveled. Then, I would measure the time taken to travel that distance.

Quick Code: egs4122

Life Skills I can share ideas I am not yet sure about.

Concept 2.3: Speed | 187

Photo Credit: aapsky / Shutterstock.com

DIGITAL

Quick Code: egst4122

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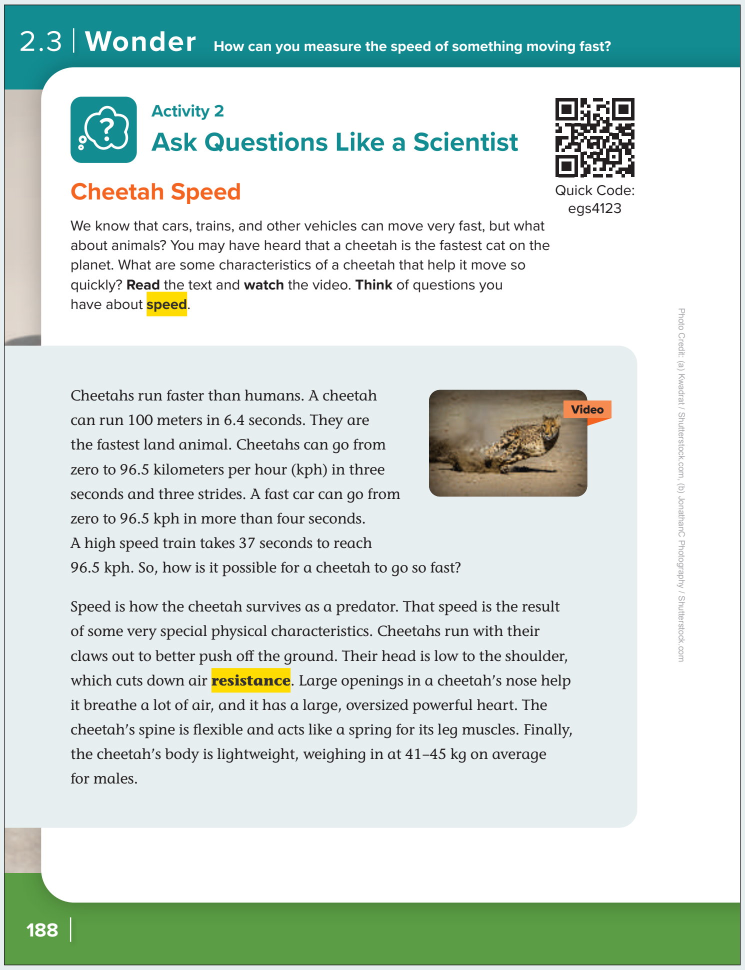

2.3 | **Wonder** How can you measure the speed of something moving fast?

Activity 2
Ask Questions Like a Scientist

Quick Code: egs4123

Cheetah Speed

We know that cars, trains, and other vehicles can move very fast, but what about animals? You may have heard that a cheetah is the fastest cat on the planet. What are some characteristics of a cheetah that help it move so quickly? **Read** the text and **watch** the video. **Think** of questions you have about **speed**.

Cheetahs run faster than humans. A cheetah can run 100 meters in 6.4 seconds. They are the fastest land animal. Cheetahs can go from zero to 96.5 kilometers per hour (kph) in three seconds and three strides. A fast car can go from zero to 96.5 kph in more than four seconds. A high speed train takes 37 seconds to reach 96.5 kph. So, how is it possible for a cheetah to go so fast?

Video

Speed is how the cheetah survives as a predator. That speed is the result of some very special physical characteristics. Cheetahs run with their claws out to better push off the ground. Their head is low to the shoulder, which cuts down air **resistance**. Large openings in a cheetah's nose help it breathe a lot of air, and it has a large, oversized powerful heart. The cheetah's spine is flexible and acts like a spring for its leg muscles. Finally, the cheetah's body is lightweight, weighing in at 41–45 kg on average for males.

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Photo Credit: JonathanC Photography / Shutterstock.com

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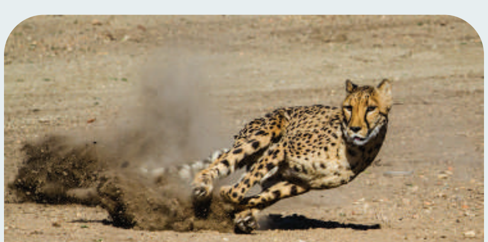

Activity 2
Ask Questions Like a Scientist
Cheetah Speed

Quick Code:
egst4123

Investigative Phenomenon

Activity 2 Ask Questions Like a Scientist

20 min

Cheetah Speed

Purpose

Students may think that only cars, trucks, and other vehicles can move quickly. In this Investigative Phenomenon, students are introduced to the fastest land animal, the cheetah, and the characteristics that allow it to achieve such speed. Students are encouraged to begin thinking about the comparison of the cheetah's characteristics to those of a fast car.

Instructional Focus

In this activity, students ask questions about how much energy a cheetah possesses to run at top speeds.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Use the reading passage and video to help students create questions about the concept of speed.

Lesson 1, *continued*

Prepare students for reading the text and watching the video by asking the following:

ASK

- *What is the fastest land animal?*
- *How do you think its speed compares to a human, car, or high-speed train?*

Read the text and watch the video *Let's Investigate Cheetah Speed*, if available.

After reading the text and watching the video, ask students to record three questions in the chart and then share with the class.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- What will you organize differently next year?
- Were students able to think about new concepts, such as speed?

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Are cheetah's paws bigger or smaller than other cats? **Write** three questions you have in the chart below.

I wonder . . .

Student questions will vary.

I wonder . . .

Why does a cheetah being lightweight help it run faster?

I wonder . . .

What is air resistance and how does it affect speed?

Photo Credit: Kwadrat / Shutterstock.com

Concept 2.3: Speed | 189

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2.3 | Wonder How can you measure the speed of something moving fast?

Activity 3

Observe Like a Scientist

Objects Move at Different Speeds

Quick Code: egs4124

Have you ever played soccer and knew a teammate was passing to you, but you had to run faster to catch up to the ball? What does it mean to go faster? **Read** the text and **watch** the video. **Discuss** the relationship of time, distance, and speed.

Video

Using a timer or stopwatch to keep track of your time, you could walk up and down a soccer field in about four minutes. If you ran, you could go back and forth between the goals several times in four minutes. The fastest runners in the world can run about 15 soccer fields, or about one and a half kilometers, in four minutes. Horses are even faster. They can run up and down 15 soccer fields in four minutes. A car on the highway can go twice as fast as the horses. To go even farther in four minutes, catch a ride on a rocket. Rockets go really fast after they blast off.

As you think about time and distance, what do you notice about the speed of each object? A runner, horse, car, or rocket might all travel for the same amount of time but go different distances. How do you know which is the fastest?

Talk Together Now, talk together about how you might determine how fast something is moving.

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Activity 3

Observe Like a Scientist

Objects Move at Different Speeds

Quick Code: egst4124

Lesson 1, *continued*

Activate Prior Knowledge

Activity 3

Observe Like a Scientist

15 min

Objects Move at Different Speeds

Purpose

Students may have some ideas about the relationship between distance, time, and speed. This activity shows different objects moving for a set time so that students can start to build the connections to relate time and distance to speed.

Instructional Focus

In this activity, students observe an informal experiment to initiate their thinking about how speed can be measured.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Use the reading passage and video to help students initiate their thinking about how speed can be measured.

Lesson 1, *continued*

Prepare students for reading the text and watching the video by asking the following:

ASK
- *How far can you move in four minutes?*
- *How do you know if something moves faster than something else?*

Read the text and watch the video *Speed and Time*, if available.

Pause the video after the first 43 seconds. Ask to students to describe what was different between walking and running.
You can go a farther distance in the same amount of time if you run.

Play the rest of the video and encourage students to reflect on the relationship between time, distance, and speed.

After reading the text and watching the video, allow students to share what they observed in small groups. Circulate among them, listening for questions and disagreements to share with the class.

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2.3 | Learn How can you measure the speed of something moving fast?

What Is Speed?

Activity 4
Analyze Like a Scientist

Basics of Speed

Quick Code: egs4127

Think of a time when you were moving very quickly. Maybe you were riding in a car on the highway. Have you ever been stuck in a traffic jam? If you have, you remember that your car was moving very slowly. Objects move at different speeds around us all the time. **Read** the text and **look** at the image to learn more about speed. Then, **write** and **draw** your definition of speed.

Basics of Speed

Speed is a measurement of how fast something is moving. Speed measures the distance that an object travels over time. The speed of an object is the same no matter which direction it moves. If you move 5 meters backward every second or 5 meters forward, your speed is still 5 meters per second. Speed is displayed in units of distance over time. Therefore, to calculate an object's speed, divide the distance it travels by the time it takes to travel there. Some common units of speed are meters per second (m/sec) and kilometers per hour (km/hr or kph).

Traffic Sign

Concept 2.3: Speed | 191

DIGITAL

Activity 4
Analyze Like a Scientist
Basics of Speed

Quick Code:
egst4127

Lesson 2

What Is Speed?

Activity 4
Analyze Like a Scientist

25 min

Basics of Speed

Purpose

This activity builds on what students already know about speed from experience and introduces the term as a scientific concept. Students consider examples of speed and how to compare different speeds.

Instructional Focus

In this activity, students generate an explanation of speed based on evidence from the scientific text.

Strategy

At this age, all students have some knowledge of speed. Running with each other on the playground, racing toy cars, traveling on various modes of transportation; all these experiences have provided them with context to begin discussing speed within an academic framework. Use familiar scenarios as access points for students to connect the study of physics to the real world.

Before students read the text describing speed, have them look at the image within the text.

ASK

- *Where have you seen a sign like this before?*
  Student answers will vary.
- *What information is this image telling you?*
  The speed limit is 80 kilometers per hour.

Lesson 2, *continued*

Guide student discussion toward speed and the comparison of speeds of cars.

As students read the text, have them highlight information they can use as evidence to support their initial ideas on the Can You Explain? question or the original question they generated during Wonder. Students should record evidence throughout the Learn section.

After students read, have them write a definition of *speed* in their own words and include an image to help explain it.

ASK

- *How do we measure the speed of an object?*
  We measure the total distance traveled and the amount of time it takes to travel that distance.
- *What are some standard units we use to measure and describe time, distance, and speed?*
  meters per second (m/sec), kilometers per hour (km/hr)

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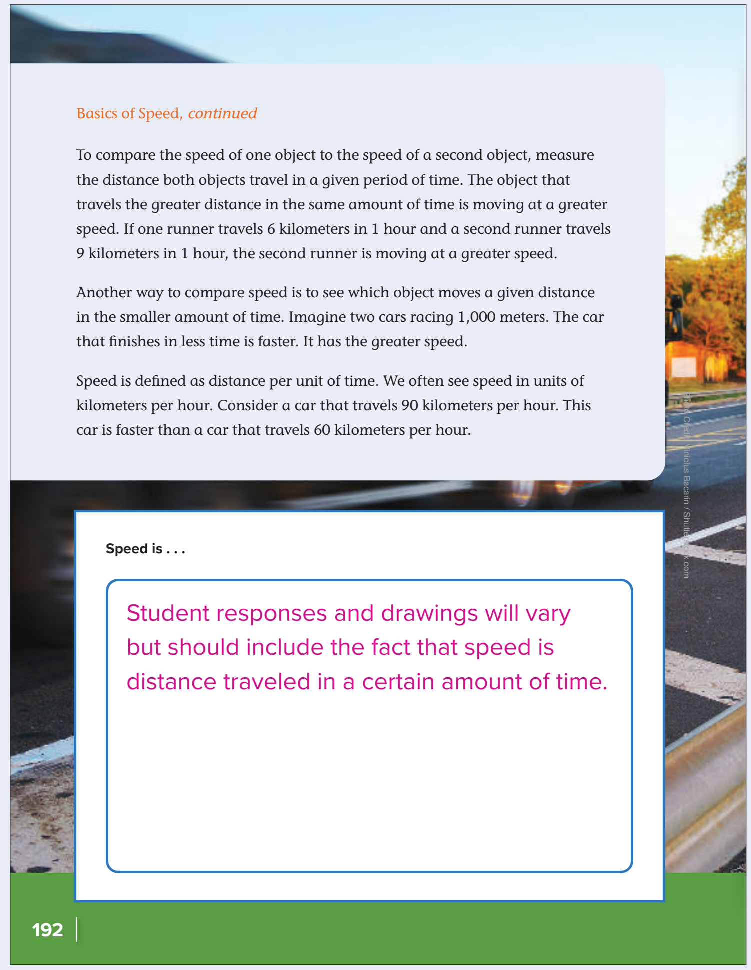

Basics of Speed, *continued*

To compare the speed of one object to the speed of a second object, measure the distance both objects travel in a given period of time. The object that travels the greater distance in the same amount of time is moving at a greater speed. If one runner travels 6 kilometers in 1 hour and a second runner travels 9 kilometers in 1 hour, the second runner is moving at a greater speed.

Another way to compare speed is to see which object moves a given distance in the smaller amount of time. Imagine two cars racing 1,000 meters. The car that finishes in less time is faster. It has the greater speed.

Speed is defined as distance per unit of time. We often see speed in units of kilometers per hour. Consider a car that travels 90 kilometers per hour. This car is faster than a car that travels 60 kilometers per hour.

Speed is . . .

Student responses and drawings will vary but should include the fact that speed is distance traveled in a certain amount of time.

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Activity 5

Observe Like a Scientist

Measuring an Object's Motion

Quick Code: egs4128

How far is your house from your school? How long does it take you to get there? If you know the answers to these two questions, you can find out the speed at which you travel. **Read** the text that follows and **watch** the video to find out how to calculate and describe speed. **Underline** the sentence that explains which two pieces of information you need to know to calculate speed. **Circle** one example of the units of measurement used to describe speed.

Have you ever been on a trip? Was it close to home or far away? How far two places are from one another is the distance between them. If you traveled far away, it may have taken a long time to get there. How long it takes to travel a distance depends on how fast you are moving. If you walk somewhere, it will take you longer to get there than if you travel on a faster moving bicycle. Something that moves as quickly as an airplane or high-speed train can cover a long distance in a short period of time.

Video

Speed is the measurement of how fast something is moving. Faster moving things have higher speeds, and slower moving things have lower speeds. You can find the speed that something is moving by doing some simple math.

Life Skills I can use information to solve a problem.

Photo Credit: Vinicius Bacarin / Shutterstock.com, (b) Thierry Weber / Shutterstock.com

Concept 2.3: Speed | 193

DIGITAL

Activity 5
Observe Like a Scientist
Measuring an Object's Motion

Quick Code:
egst4128

Activity 5

Observe Like a Scientist

20 min

Measuring an Object's Motion

Purpose

Now that students are familiar with the basics of speed, they are ready to take a closer look at the relationship between time and distance. With this understanding, students will be able to make accurate speed calculations in subsequent activities.

Instructional Focus

In this activity, students look for evidence to explain what information is necessary to make speed calculations.

Life Skills **Problem-Solving**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning

Before reading the text or watching the video, ask students to recall a time that they went on a trip and how they made the journey (on foot, in a car, or in an airplane). Ask students to consider the different speeds at which we can travel, discussing which is the fastest mode of transportation versus the slowest.

ASK *What information do we need to know in order to find out at what speed a vehicle was traveling when it made a trip?*
Student answers will vary. Some students may understand that how far you traveled (distance) and how long it took (time) are important factors in being able to determine speed.

Provide students time to read the text and watch the video. Then, discuss in pairs. Ask students to complete the student response task together. As students discuss their ideas, circulate among them, listening for misconceptions and questions.

Lesson 3

How Do I Calculate Speed?

Activity 6
Investigate Like a Scientist

45 min

Hands-On Investigation: Measuring Speed

Purpose

Hands-On Investigations allow students to apply their understanding of abstract concepts to a practical situation. In this investigation, students use what they know about the relationship between time and distance to calculate speed.

Instructional Focus

In this activity, students work in groups to measure the speed of various balls traveling down a ramp.

Life Skills **Collaboration**

Activity Activator: Make a Prediction

Students may have heard the term *speed* used or described in their personal experiences. In previous activities, students learned the scientific definition of speed and how to calculate it. This activity builds upon students' basic knowledge of both speed and energy. The faster an object moves, the more energy it has. Students may already understand this concept based on experience. This investigation allows them to measure, record, and analyze data to provide evidence of this scientific principle.

Materials List (per group)

- 30-centimeter ramp
- 3 balls of varying size and type, such as tennis balls, golf balls, marbles, or table-tennis balls
- Meterstick or measuring tape
- Masking tape
- Books
- Stopwatch
- Balance (optional)

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Follow proper disposal and cleaning procedures after the lab.
- Wear proper safety attire, including closed-toe shoes, safety goggles, lab coats or aprons, and gloves.
- Tie back long hair.
- Do not eat or drink anything in the lab.

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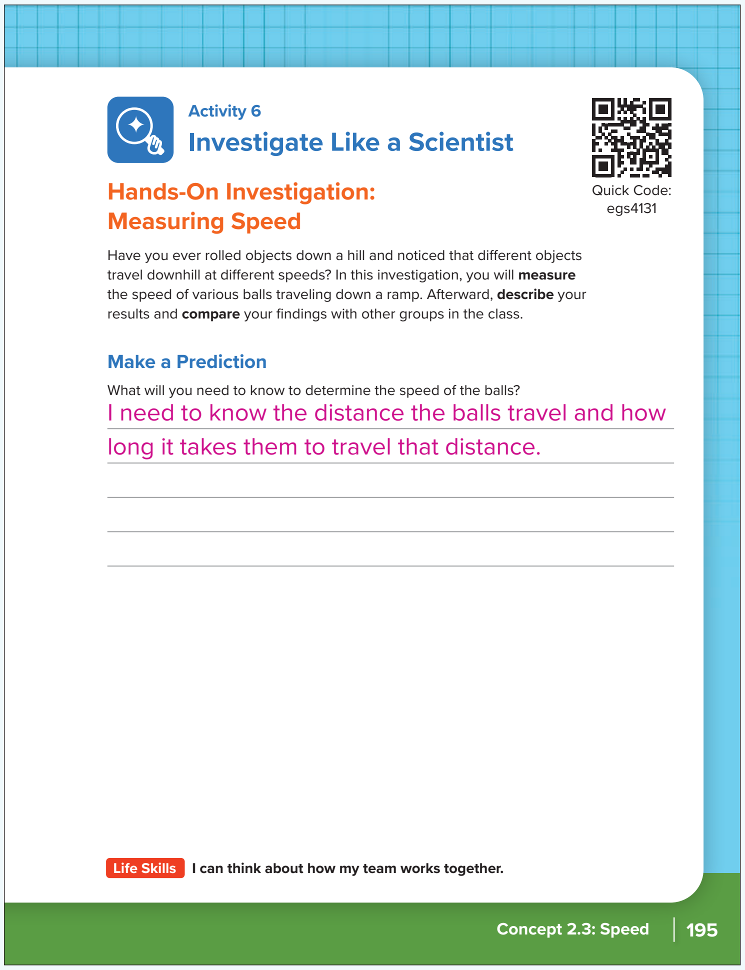

Activity 6

Investigate Like a Scientist

Quick Code: egs4131

Hands-On Investigation: Measuring Speed

Have you ever rolled objects down a hill and noticed that different objects travel downhill at different speeds? In this investigation, you will **measure** the speed of various balls traveling down a ramp. Afterward, **describe** your results and **compare** your findings with other groups in the class.

Make a Prediction

What will you need to know to determine the speed of the balls?

I need to know the distance the balls travel and how long it takes them to travel that distance.

Life Skills I can think about how my team works together.

Concept 2.3: Speed | 195

DIGITAL

Activity 6

Investigate Like a Scientist

Hands-On Investigation: Measuring Speed

Quick Code: egst4131

Lesson 3, *continued*

To begin, review the definition of *speed* with students. Students should know that speed is the distance an object moves over a certain amount of time. Introduce the activity, telling students that they will observe balls rolling down the ramp. Ask students to predict which ball they think will move down the ramp the fastest.

Activity Procedure: What Will You Do?

Part 1: Conduct the Investigation

1. Help students set up their ramps if necessary. (Note: the lower the ramp, the slower the object will travel down it.) Use books to set the height of the ramp. All students should set their ramps to the same height. Ask students to draw a simple sketch of their investigation set-up.
2. Measure 1 meter from the bottom edge of the ramp and place a piece of tape on the floor as a finish line.
3. Challenge students to figure out what information they will need to know to measure the ball's speed as it rolls down the ramp. (Students will need to know the distance the ball travels and the amount of time it takes the ball to roll down the ramp.)
4. Next, students will roll a variety of balls down the ramp, one at a time. Students need to gently let go of the ball and not forcefully roll it down the ramp. The balls should be different sizes and weights.
5. Groups should have one student roll the ball, one student operate the stopwatch, and one student record the data. If groups have more than three students, students should take turns in the different roles. The timer should start the stopwatch when the ball is released at the top of the ramp and stop the stopwatch when the ball crosses the finish line.
6. Students can record their data in a T-chart with the labels "Type of Ball" and "Time (seconds)."

Lesson 3, *continued*

7. After groups have rolled the first ball, pause the activity so that all students can practice describing the speed. For example, students should accurately describe the speed and use correct units, such as "The tennis ball traveled 1 meter in 2 seconds."
8. Circulate around the room as students repeat the process for all of their different balls, checking to be sure that students are not changing the height of the ramp and not forcing the balls down the ramp.

Part 2: Sharing Data

After students have finished the investigation, provide them with time to complete the section Think About the Activity.

Call on representatives from each group to share their findings. Record the outcomes of each teams' investigations in a space visible to the whole class. Allow time for students to discuss any patterns or generalizations that they can make based on the class data.

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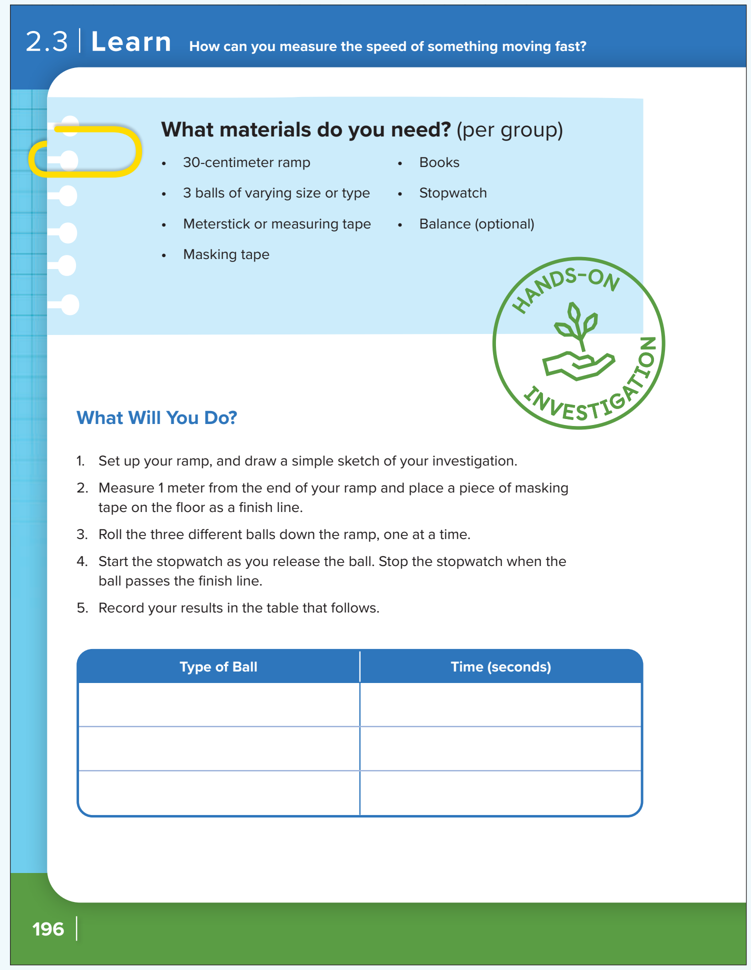
2.3 | Learn How can you measure the speed of something moving fast?

What materials do you need? (per group)

- 30-centimeter ramp
- 3 balls of varying size or type
- Meterstick or measuring tape
- Masking tape
- Books
- Stopwatch
- Balance (optional)

HANDS-ON INVESTIGATION

What Will You Do?

1. Set up your ramp, and draw a simple sketch of your investigation.
2. Measure 1 meter from the end of your ramp and place a piece of masking tape on the floor as a finish line.
3. Roll the three different balls down the ramp, one at a time.
4. Start the stopwatch as you release the ball. Stop the stopwatch when the ball passes the finish line.
5. Record your results in the table that follows.

Type of Ball	Time (seconds)

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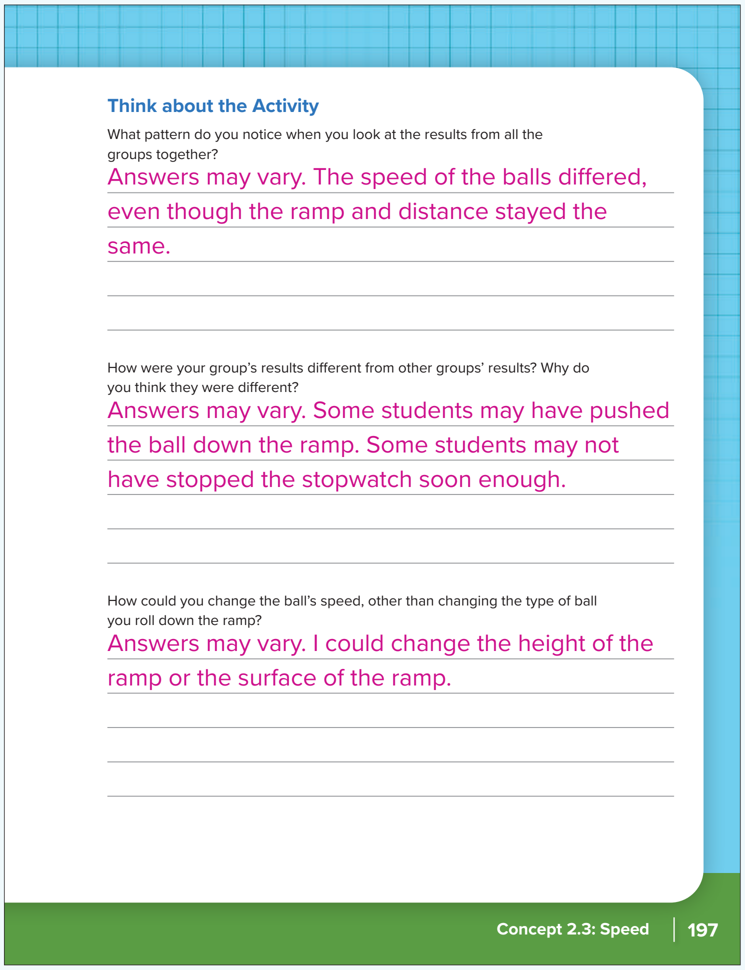

Think about the Activity

What pattern do you notice when you look at the results from all the groups together?

Answers may vary. The speed of the balls differed, even though the ramp and distance stayed the same.

How were your group's results different from other groups' results? Why do you think they were different?

Answers may vary. Some students may have pushed the ball down the ramp. Some students may not have stopped the stopwatch soon enough.

How could you change the ball's speed, other than changing the type of ball you roll down the ramp?

Answers may vary. I could change the height of the ramp or the surface of the ramp.

Concept 2.3: Speed | 197

Analysis and Conclusions: Think About the Activity

ASK

- *What pattern do you notice when you look at the results from all the groups together?*
  Answers may vary. The speed of the balls differed, even though the ramp and distance stayed the same.
- *How were your group's results different from other groups' results? Why do you think your results were different?*
  Answers may vary. Some students may have pushed the ball down the ramp. Some students may not have stopped the stopwatch soon enough.
- *How could you change the ball's speed, other than changing the type of ball you roll down the ramp?*
  Answers may vary. I could change the height of the ramp or the surface of the ramp.

Lesson 4

Activity 7
Analyze Like a Scientist

10 min

Calculating Speed

Purpose

At this point, students have a deep understanding of speed as it relates to distance and time. In this activity students review the process for and practice calculating speed.

Instructional Focus

Students apply mathematical and computational thinking to solve real-world problems and compare speeds using provided distance and time information.

Life Skills **Collaboration**

Strategy

- Engage students with the text and challenge students to calculate the speed of a yellow car that travels 10 meters in 5 seconds and a green car that travels 20 meters in 5 seconds. *2 m/s and 4 m/s*
- Ask students to share their answers and explain how they performed their calculations. Write the formula for calculating speed (speed=distance/time) in a place that students can refer to it as they make further calculations.
- Engage students in a four corners strategy by writing each problem on a piece of paper or poster board and taping problems to different corners of the room.
    - Amir rides his bike 10 kilometers in 1 hour. How fast is he going? *10 km/h*
    - Nour rides her bike 20 kilometers in 2 hours. How fast is she going? *10 km/h*
    - Omar rides his bike 15 kilometers in 3 hours. How fast is he going? *5 km/h*
    - Rashida rides her bike 30 kilometers in 2 hours. How fast is she going? *15 km/h*

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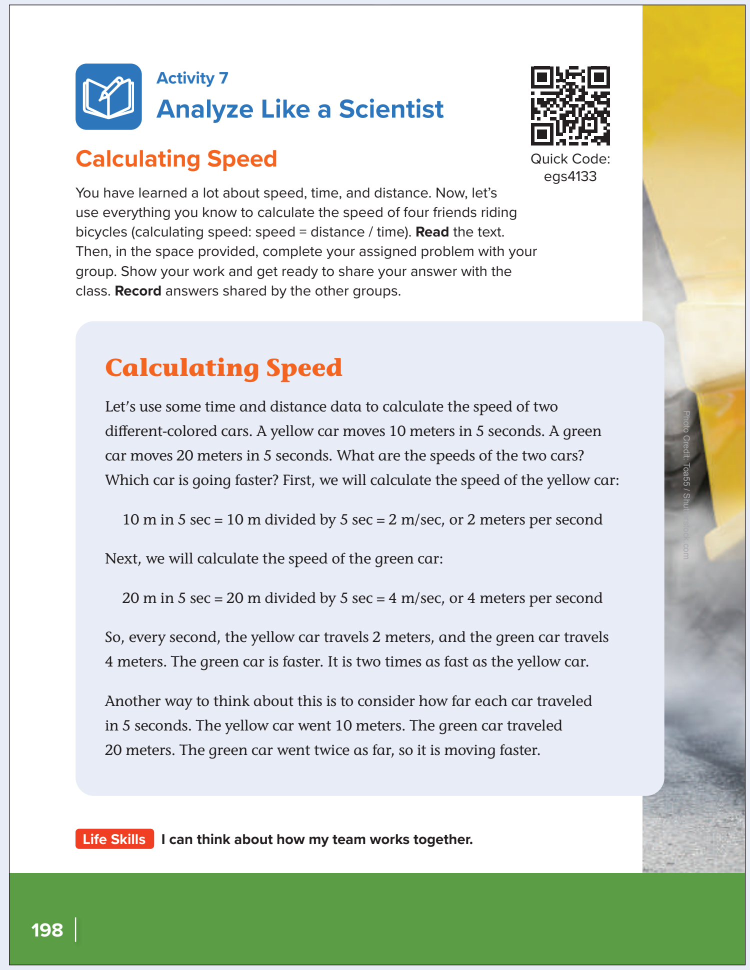
Activity 7
Analyze Like a Scientist

Calculating Speed

Quick Code: egs4133

You have learned a lot about speed, time, and distance. Now, let's use everything you know to calculate the speed of four friends riding bicycles (calculating speed: speed = distance / time). **Read** the text. Then, in the space provided, complete your assigned problem with your group. Show your work and get ready to share your answer with the class. **Record** answers shared by the other groups.

Calculating Speed

Let's use some time and distance data to calculate the speed of two different-colored cars. A yellow car moves 10 meters in 5 seconds. A green car moves 20 meters in 5 seconds. What are the speeds of the two cars? Which car is going faster? First, we will calculate the speed of the yellow car:

10 m in 5 sec = 10 m divided by 5 sec = 2 m/sec, or 2 meters per second

Next, we will calculate the speed of the green car:

20 m in 5 sec = 20 m divided by 5 sec = 4 m/sec, or 4 meters per second

So, every second, the yellow car travels 2 meters, and the green car travels 4 meters. The green car is faster. It is two times as fast as the yellow car.

Another way to think about this is to consider how far each car traveled in 5 seconds. The yellow car went 10 meters. The green car traveled 20 meters. The green car went twice as far, so it is moving faster.

Life Skills I can think about how my team works together.

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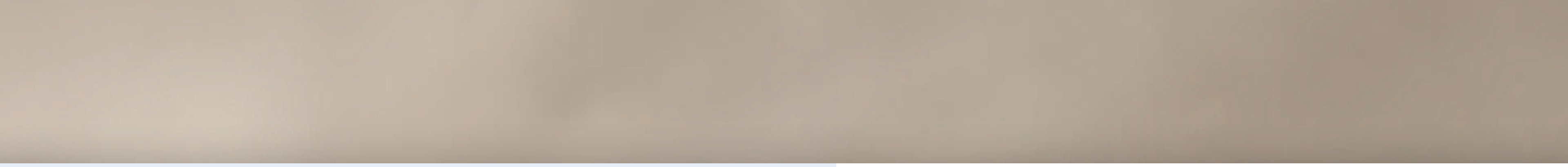
Activity 7
Analyze Like a Scientist
Calculating Speed

Quick Code:
egst4133



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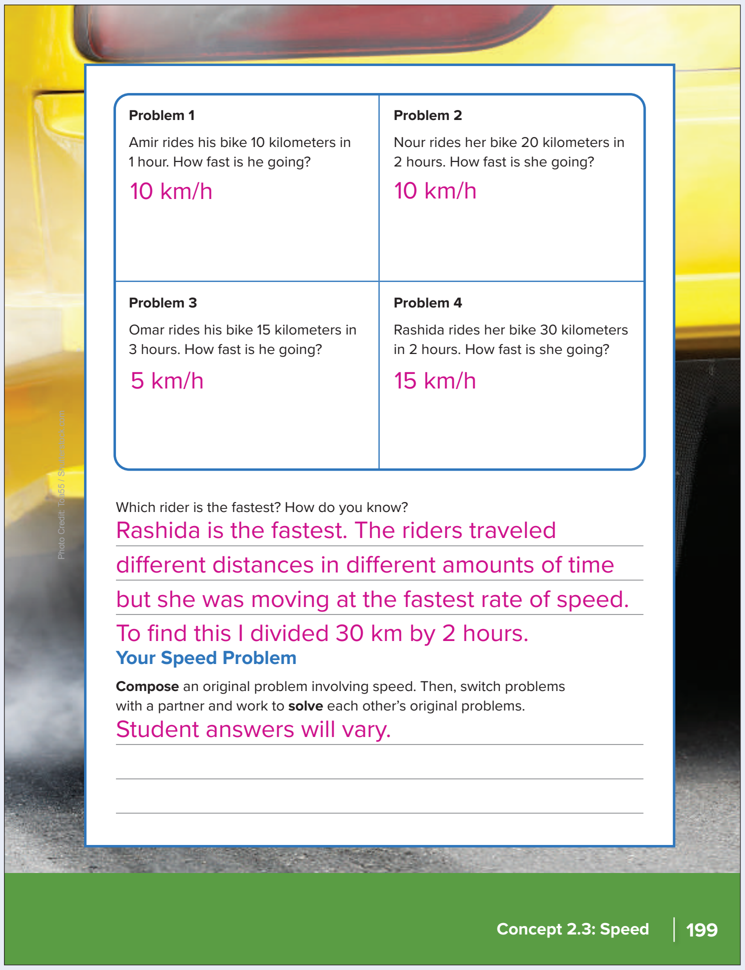

Problem 1	Problem 2
Amir rides his bike 10 kilometers in 1 hour. How fast is he going? 10 km/h	Nour rides her bike 20 kilometers in 2 hours. How fast is she going? 10 km/h
Problem 3 Omar rides his bike 15 kilometers in 3 hours. How fast is he going? 5 km/h	**Problem 4** Rashida rides her bike 30 kilometers in 2 hours. How fast is she going? 15 km/h

Which rider is the fastest? How do you know?

Rashida is the fastest. The riders traveled different distances in different amounts of time but she was moving at the fastest rate of speed. To find this I divided 30 km by 2 hours.

Your Speed Problem

Compose an original problem involving speed. Then, switch problems with a partner and work to **solve** each other's original problems.

Student answers will vary.

Concept 2.3: Speed | 199

Lesson 4, *continued*

- Assign students to different corners to work on the problems together. (You may want to count off or use another method to divide students equally.) Tell students that they must work together to solve the problem and record their work. Ask one student from each corner to share with the whole class.
- Discuss results with students. Call attention to the riders who traveled a different distance but in the same amount of time and riders who rode at the same speeds but for a different distance.
- Encourage students to create their own problem related to speed. Students then switch problems with a partner, and work to solve each other's original problems.

Lesson 4, *continued*

What Is the Relationship between Speed and Kinetic Energy?

Activity 8
Investigate Like a Scientist

35 min

Hands-On Investigation: Racing Downhill

Purpose

At this point in the concept, students can make speed calculations with confidence. Students have explored how the speed of an object can vary depending on the object. As students work toward exploring what happens when objects collide, they investigate a new variable: how slope affects speed and energy.

Instructional Focus

In this activity, students use model cars or trucks to measure the speed and kinetic energy of objects moving down inclines of various angles.

Life Skills **Accountability**

Activity Activator: Make a Prediction

To introduce the activity, ask students for ideas on how to measure the speed of a moving object, such as a car or an athlete running. Point out that police officers use radar to track the speed of moving cars and coaches use a stopwatch to measure the speed of athletes.

Materials List (per group)

- Toy trucks
- Cardboard paper towel tube
- Paper cup, 360 mL
- Scissors
- Several books
- Metric ruler
- Removable sticky note flags
- Stopwatch

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Be careful using sharp objects such as scissors, glass jars, and other equipment.
- Follow proper disposal and cleaning procedures after the lab.
- Wear proper safety attire including closed toe shoes, safety goggles, lab coats or aprons, and gloves.
- Tie back long hair.
- Do not eat or drink anything in the lab.

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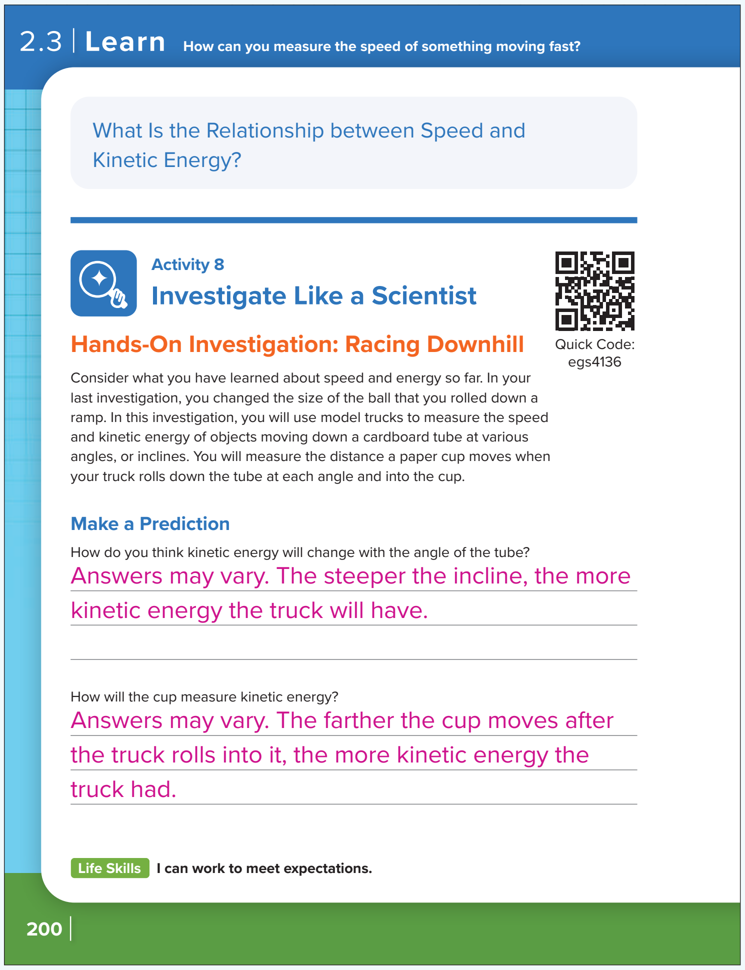

2.3 | **Learn** How can you measure the speed of something moving fast?

What Is the Relationship between Speed and Kinetic Energy?

Activity 8

Investigate Like a Scientist

Quick Code: egs4136

Hands-On Investigation: Racing Downhill

Consider what you have learned about speed and energy so far. In your last investigation, you changed the size of the ball that you rolled down a ramp. In this investigation, you will use model trucks to measure the speed and kinetic energy of objects moving down a cardboard tube at various angles, or inclines. You will measure the distance a paper cup moves when your truck rolls down the tube at each angle and into the cup.

Make a Prediction

How do you think kinetic energy will change with the angle of the tube?

Answers may vary. The steeper the incline, the more kinetic energy the truck will have.

How will the cup measure kinetic energy?

Answers may vary. The farther the cup moves after the truck rolls into it, the more kinetic energy the truck had.

Life Skills **I can work to meet expectations.**

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DIGITAL

Activity 8

Investigate Like a Scientist

Hands-On Investigation:
Racing Downhill

Quick Code:
egst4136

Lesson 4, *continued*

Then, explain that another way to measure a moving object's speed is by measuring its kinetic energy, or how far it can move an object at rest. Tell students that in this activity, they will be rolling toy trucks down cardboard tubes into a paper cup and measuring how far the truck moves the cup.

Activity Procedure: What Will You Do?

Part 1: Measuring Speed

Divide students into pairs. Explain that one student will roll the car or truck down the cardboard tube and the other will measure its speed. Remind students that they should not push the trucks or try to make them move too quickly but that they are measuring the natural speed.

1. Students place one end of the cardboard tube on top of one of their books, with the other end resting on a table, or the floor.
2. Students record the number of books used. The number of books will represent the incline angle.
3. One student holds the stopwatch while the other places the truck at the upper edge of the tube. The student with the truck will then release the truck so it rolls down the tube while the student with the stopwatch captures its time.
4. Students record the time of the trial next to the number of books used.
5. Students increase the angle of incline by adding another book, then repeat the experiment. Students then add a second book and perform the experiment a third time.

Lesson 4, *continued*

Part 2: Measuring Kinetic Energy

Inform students that they will now be testing how the truck's kinetic energy changes as the angle of incline changes.

1. Students remove all but the original book, then replace the truck and tube.
2. Students cut a hole in the side of their cup, large enough to allow the truck to enter without hitting any of its edges.
3. Students place the cup upside down on the table or floor at the lower end of the cardboard tube, with the "tunnel entrance" facing the tube's opening. Have one student mark the position of the cup with a sticky note flag.
4. One student releases the truck. It will roll down the tube and into the cup, moving the cup away from its original position. When the cup stops, have the other student mark its new location with a second sticky note flag.
5. Students measure the distance between the two sticky note flags with their ruler and record the measurement in the data table.
6. Students increase the angle of incline by adding another book, then repeat the experiment. Then, have them add a second book and perform the experiment a third time.

Analysis and Conclusions: Think About the Activity

ASK

- *What happened to the speed of the truck when the incline increased?*
  Answers may vary. The greater the incline, the faster the truck went.

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What materials do you need? (per group)

- Toy trucks
- Cardboard paper towel tube
- Paper cup, 360 mL
- Scissors
- Several books
- Metric ruler
- Removable sticky note flags
- Stopwatch

HANDS-ON INVESTIGATION

What Will You Do?

1. With your partner, record the number of books used to set up your tube in the column Number of Books.
2. Roll your truck down the tube, use the stopwatch to keep time, and record how long the truck takes to travel to the end of the tube in the column Time to Travel.
3. Add a book to change the incline angle and repeat the steps. Add a second book and repeat the steps again.
4. Now, repeat each incline, but place a cup at the bottom of the tube.
5. Measure the distance the cup moves after each time the truck rolls into it.

Number of Books	Time to Travel	Distance the Cup Traveled
Answers will vary.		

Concept 2.3: Speed | 201

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2.3 | **Learn** How can you measure the speed of something moving fast?

Think About the Activity

What happened to the speed of the truck when the incline increased?

Answers may vary. The greater the incline, the faster the truck went.

How did the results of the speed test compare to the results of the kinetic energy test?

Answers may vary. Both speed and kinetic energy increased as the angle of the incline increased.

What conclusion can you draw about the relationship between speed and kinetic energy, based on this experiment?

Answers may vary. As speed increases, so does kinetic energy. Objects that have more speed have more energy that can be transferred.

Lesson 4, *continued*

- *How did the results of the speed test compare to the results of the kinetic energy test?*
  Answers may vary. Both speed and kinetic energy increased as the angle of the incline increased.
- *What conclusion can you draw about the relationship between speed and kinetic energy, based on this experiment?*
  Answers may vary. Speed and kinetic energy have a direct relationship. Kinetic energy can be used to measure speed, and vice versa.

Differentiation

ADVANCED LEARNERS

As you work with students throughout this lesson, help them develop their understanding of forces and their relationship to an object's speed. Their explorations of the resources in this lesson should prepare them for more advanced concepts such as Newton's laws; they will also help them better understand the close relationship between speed and motion.

APPROACHING LEARNERS

The multiple steps in this activity may be challenging for some students to follow. You may wish to model the steps to small groups of students and then ask them to repeat without assistance. Continue to ask students to connect distance, motion, and speed based on observations.

Teacher Reflection

- Can my students identify the strengths and weaknesses of models?
- What data did my students struggle with during the Hands-On Investigation?
- What other examples of kinetic energy being used as a way to measure speed could I include the next time I teach this lesson?

Lesson 5

How are Speed and Energy Related?

Activity 9
Analyze Like a Scientist

15 min

Changing Speed

Purpose

Students have been measuring and comparing speeds of various objects. This lesson connects two ideas students have been exploring: speed and the forms of energy (potential and kinetic).

Instructional Focus

In this activity, students use the information from a text about the relationship between speed and forces to construct an explanation for how to change a car's speed.

Strategy

Provide students with the text that describes the relationship between changes in speed and force.

Prior to reading the text,

ASK *How do you make a car speed up and slow down?*
You can reduce or increase the force applied to the vehicle to change the speed.

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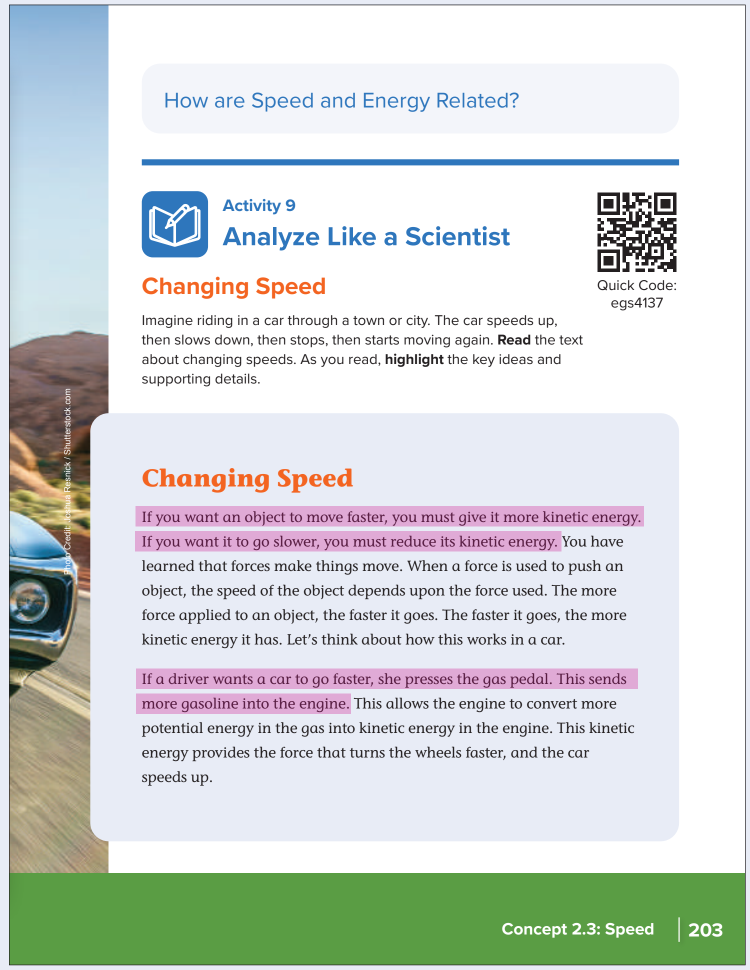
How are Speed and Energy Related?

Activity 9
Analyze Like a Scientist

Quick Code: egs4137

Changing Speed

Imagine riding in a car through a town or city. The car speeds up, then slows down, then stops, then starts moving again. **Read** the text about changing speeds. As you read, **highlight** the key ideas and supporting details.

Changing Speed

If you want an object to move faster, you must give it more kinetic energy. If you want it to go slower, you must reduce its kinetic energy. You have learned that forces make things move. When a force is used to push an object, the speed of the object depends upon the force used. The more force applied to an object, the faster it goes. The faster it goes, the more kinetic energy it has. Let's think about how this works in a car.

If a driver wants a car to go faster, she presses the gas pedal. This sends more gasoline into the engine. This allows the engine to convert more potential energy in the gas into kinetic energy in the engine. This kinetic energy provides the force that turns the wheels faster, and the car speeds up.

Concept 2.3: Speed | 203

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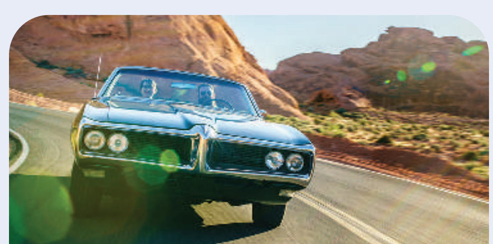

Activity 9
Analyze Like a Scientist
Changing Speed

Quick Code:
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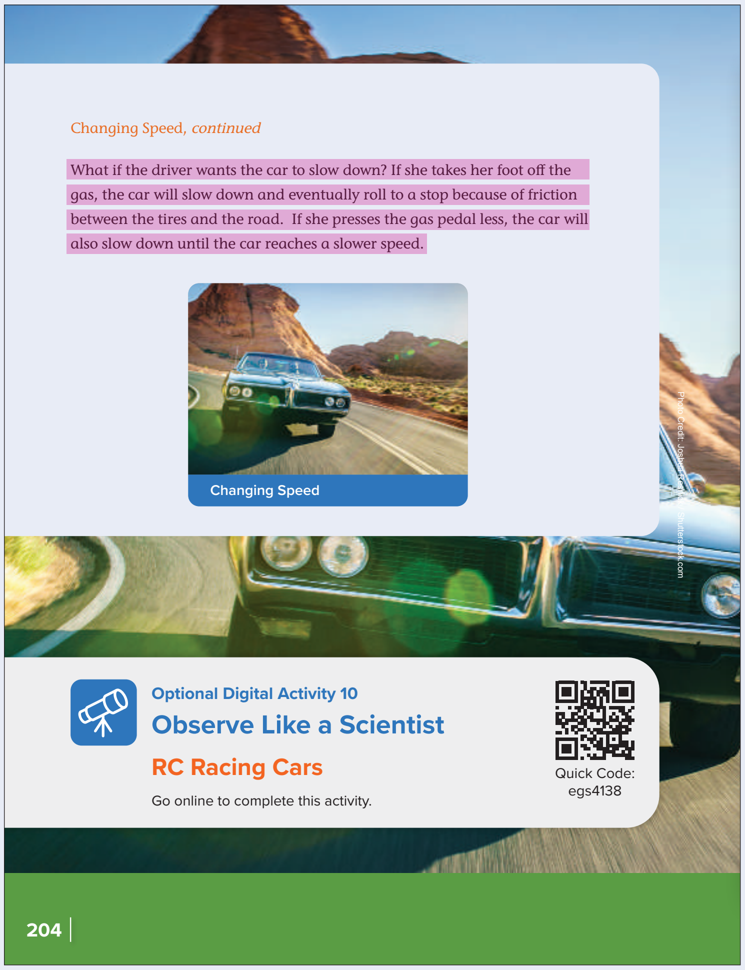

Changing Speed, continued

What if the driver wants the car to slow down? If she takes her foot off the gas, the car will slow down and eventually roll to a stop because of friction between the tires and the road. If she presses the gas pedal less, the car will also slow down until the car reaches a slower speed.

Changing Speed

Optional Digital Activity 10

Observe Like a Scientist

RC Racing Cars

Go online to complete this activity.

Quick Code: egs4138

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Lesson 5, *continued*

Have students read the text. Students should highlight the key ideas and supporting details of the text. Then, tell students to discuss 1 to 2 key ideas from the text with a partner. Remind them to refer back to the text for evidence.

Optional Digital Activity 10
Observe Like a Scientist

15 min

RC Racing Cars

This optional activity can be found online. Optional digital activities can be used to extend student exploration or to challenge advanced students.

Quick Code: egst4138

Lesson 5, *continued*

Activity 11
Evaluate Like a Scientist

10 min

Train Race

Purpose

This formative assessment asks students to apply what they have learned about speed to a new situation. This activity serves as a check for understanding before students compose a scientific explanation for what they have learned.

Instructional Focus

In this activity, students analyze data about model trains to generate claims based on evidence from the data.

Strategy

During this formative assessment, instruct students to read the text and answer the questions for the item Train Race. This is a good opportunity to compare student answers and check for understanding before moving forward in instruction.

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Activity 11
Evaluate Like a Scientist

Quick Code: egs4139

Train Race

Use what you now know about speed to compare model trains in the scenario given. **Read** the text and then **answer** the question.

Ahmed loves model trains. He wants to get one that is faster than the one he has now. The train catalog gives the speed for a new train: it travels 4 meters every 8 seconds. Ahmed tested his old train on his 3-meter track so he could compare it to the new train in the catalog. His old train traveled 3 meters in 12 seconds.

Should Ahmed buy the new train? **Explain** your reasoning using calculations of speed from the data.

Ahmed should buy the new train because it is faster. The old train moves at a rate of $\frac{1}{4}$ (0.25) meter per second. The new train can move at a rate of $\frac{1}{2}$ (0.5) meter per second.

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Activity 11
Evaluate Like a Scientist
Train Race

Quick Code:
egst4139

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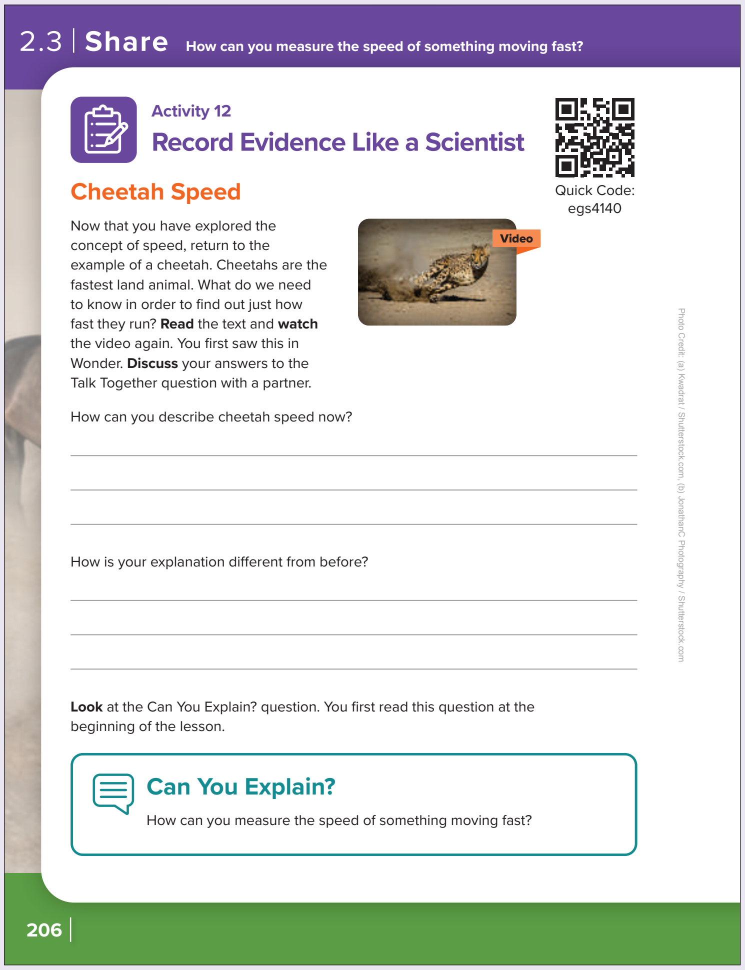
2.3 | Share How can you measure the speed of something moving fast?

Activity 12
Record Evidence Like a Scientist

Quick Code: egs4140

Cheetah Speed

Now that you have explored the concept of speed, return to the example of a cheetah. Cheetahs are the fastest land animal. What do we need to know in order to find out just how fast they run? **Read** the text and **watch** the video again. You first saw this in Wonder. **Discuss** your answers to the Talk Together question with a partner.

How can you describe cheetah speed now?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?
How can you measure the speed of something moving fast?

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Quick Code:
egst4140

Photo Credit: JonathanC Photography / Shutterstock.com

Lesson 5, *continued*

Scientific Explanation

Activity 12
Record Evidence Like a Scientist

20 min

Cheetah Speed

Purpose

In this activity, students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students construct explanations about the Investigative Phenomenon Cheetah Speed and the Can You Explain? question or a question of their own.

Strategy

Display the Investigative Phenomenon of the *Cheetah Speed* video, text, and Can You Explain? question.

Review the Let's Investigate Cheetah Speed text and video, if available. Use the text, or while watching the video as a class, pause at the 45-second mark and allow students a moment to record the data shared. The cheetah ran 100 meters in 6.4 seconds. Explain that students will come back to these numbers after the video.

Then, read the rest of the text or play the remainder of the video. Remind students that the formula for calculating speed is distance divided by time. Since this calculation involves decimal points, do it together as a class using a calculator.

Lesson 5, *continued*

Describe how the distance the cheetah traveled (100 meters) divided by the time the cheetah ran (6.4 seconds) calculates to a speed of 15.625 meters per second. Have students round up to the next whole number in their notes to describe the cheetah's speed as 16 meters per second. Have students turn and talk with a partner to discuss the following questions.

ASK
- *How can you describe cheetah speed now?*
- *How is your explanation different from before?*
- *How can this explanation help you answer the Can You Explain? question?*

As students would have already reviewed sample scientific explanations in earlier units, they should be familiar with the claim, reasoning, and evidence framework. You may want to review the following:

A **claim** is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with *yes* or *no*.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use information from text, video, or data that supports the claim. Leave out information that doesn't support the claim.

Reasoning ties together the claim and the evidence.

- Shows how or why the data count as evidence to support the claim.
- Provides the justification for why this evidence is important to this claim.
- Includes one or more scientific principles that are important to the claim and evidence.

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Use your new ideas about speed to answer the Can You Explain? question. To plan your scientific explanation, first **write** your claim. Your claim is a one-sentence answer to the question you investigated. It answers, What can you conclude? It should not start with *yes* or *no*.

My claim:
Answers will vary.

Then, **record** your evidence. Next, **consider** and **explain** how your evidence supports your claim.

Evidence	Reasoning That Supports Claim
Speed is the measurement of how fast something is moving. You could calculate the speed of a passing car by finding the distance the car traveled and how long it took the car to get there. If you know these two things, then you will be able to measure how fast the car is going.	During the Hands-On Investigation: Measuring Speed, I learned to measure the distance that a ball is traveling and the time it takes to travel that distance. I also saw this type of calculating done in the cheetah video, when the researcher set the timer as the cheetah ran 100 meters.

Concept 2.3: Speed | 207

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2.3 | **Share** How can you measure the speed of something moving fast?

Now, **write** your scientific explanation.

Speed is the measurement of how fast something is moving. You could calculate the speed of a passing car by finding the distance the car traveled and how long it took the car to get there. If you know these two things, then you will be able to calculate how fast the car is going. To do this accurately, I would use the procedures in the Hands-On Investigation Measuring Speed. I learned to measure the distance that a ball is traveling and the time it takes to travel that distance. We saw this in the cheetah video, when the researcher set the timer as the cheetah ran 100 meters. In the activity Racing Downhill, we collected evidence that the faster an object moves, the more kinetic energy it has. A cheetah running has more kinetic energy than someone sitting down on a chair.

Can You Explain?

How can you measure the speed of something moving fast?

After providing scaffolding to students, for those students able to do so, allow them to construct a full scientific explanation. Students can write, draw, or orally describe their claim, evidence, and reasoning.

Sample student response:

Speed is the measurement of how fast something is moving. You could measure the speed of a passing car by finding out the distance the car traveled and how long it took the car to get there. If you know these two things, then you will be able to measure how fast the car is going. To do this accurately, I would use the procedures in the Hands-On Investigation Measuring Speed. I learned to measure the distance that a ball is traveling and the time it takes to travel that distance. We saw this in the cheetah video, when the researcher set the timer as the cheetah ran 100 meters. In the activity Racing Downhill, we collected evidence that the faster an object moves, the more kinetic energy it has. A cheetah running has more kinetic energy than someone sitting down on a chair.

Differentiation

APPROACHING LEARNERS

For glossary terms such as *speed* and *motion*, try to include actual representations as well as textual or graphical formats to help students better conceptualize each term's meaning. Have materials on hand that embody concepts relevant to an object's motion, distance, and time.

Lesson 6

STEM in Action

Activity 13
Analyze Like a Scientist

25 min

Solar Vehicles

Purpose

This activity uses the example of solar powered vehicles to promote students' creative thinking. Students explore the role of an important profession—mechanical engineers. Students apply their understanding of speed and energy in a real-world scenario.

Instructional Focus

Students obtain information about solar vehicles to evaluate the use of solar energy related to the speed of solar vehicles.

ENTREPRENEURSHIP

Entrepreneurs suggest creative ideas for solving problems. As students read about mechanical engineers, encourage them think of how the work engineers are doing with solar vehicles shows entrepreneurial creativity. As students think of how to calculate the speed of solar vehicles, you will likely need to remind them to look for opportunities and ideas drawing on what students already know and to use the entrepreneurial skills of creativity, adding value to ideas, and setting an innovative vision.

PRINT

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STEM in Action

Quick Code: egs4141

Activity 13
Analyze Like a Scientist

Solar Vehicles

Now that you have been thinking about speed and motion, have you ever thought about designing a car? Mechanical engineers help design cars and think about how to use energy in creative ways. **Read** the text to learn more about solar powered vehicles. **Think** about whether you would like to become a mechanical engineer one day.

Solar Vehicles

Most cars run on gasoline. The use of fuel and the exhaust it produces contribute to climate change. More and more vehicles are running on electricity. Electric vehicles have batteries that must be charged. Can you imagine a car that never has to stop for gas or a charge?

Solar Cells

Mechanical engineers are designing vehicles that run on nothing but the sun. There are, of course, some difficulties. At this time, the amount of energy we can capture from the sun is not as great as the amount of energy we get from gasoline or an electric battery. How can mechanical engineers make solar vehicles drive as quickly as conventional vehicles? Among other things, they reduce the weight of the vehicle, and make other efficient changes.

Concept 2.3: Speed | 209

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Activity 13
Analyze Like a Scientist
Solar Vehicles

Quick Code:
egst4141

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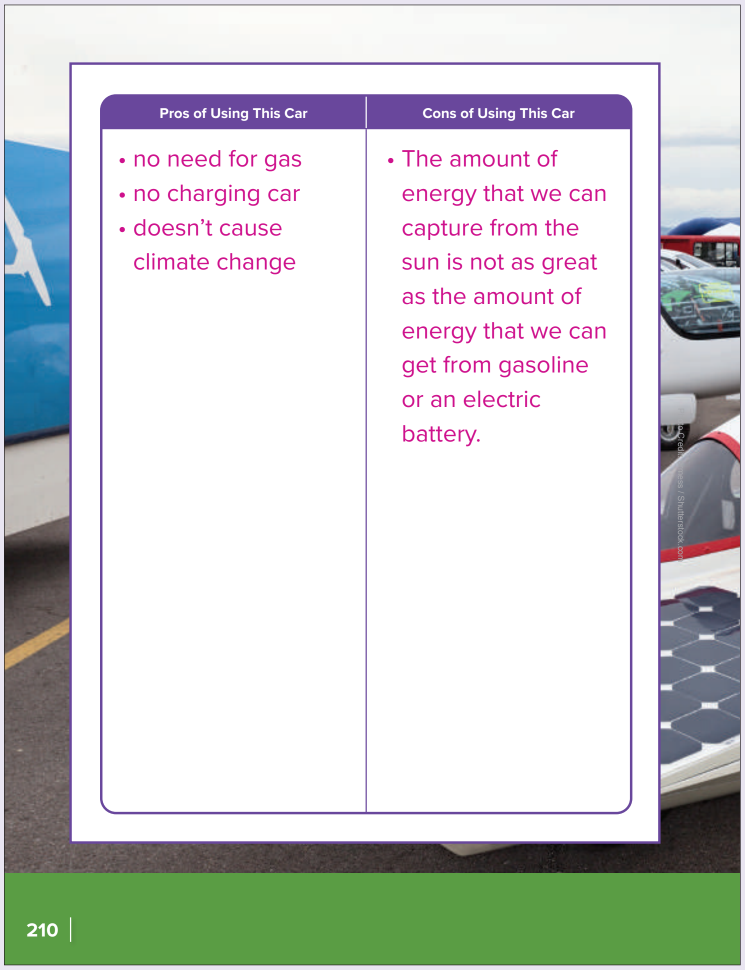

Pros of Using This Car	Cons of Using This Car
• no need for gas • no charging car • doesn't cause climate change	• The amount of energy that we can capture from the sun is not as great as the amount of energy that we can get from gasoline or an electric battery.

210

Lesson 6, *continued*

Strategy

Ask students to read about solar vehicles and to create a list of the pros and cons of using this car in a T-chart.

Lesson 6, *continued*

Solar Vehicle

Strategy

This portion of the activity can be used to generate a discussion about speed and how it relates to distance and time.

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Solar Vehicle

The solar vehicle is so lightweight that most instruments are excluded. Without a speedometer, how can we know the speed of the solar vehicle? In the following activity, you will design a way to calculate the solar vehicle's speed.

The fastest solar vehicle can go slightly more than 88 kilometers per hour. Calculating that speed can be challenging because most of the solar vehicle races take place in remote locations, and in most cases, the solar vehicles do not have speedometers. Imagine that you have been given the task of calculating the speed of the solar vehicle. How would you do it?

Solar Powered Cars

Answers will vary. To calculate the speed of the solar vehicle, I need to know the time and distance. I would record the time as the vehicle passed each of two markers placed at a set distance from each other. Subtracting the first time from the second and dividing the distance between the markers by the difference in time will tell me the speed of the solar vehicle.

Concept 2.3: Speed | 211

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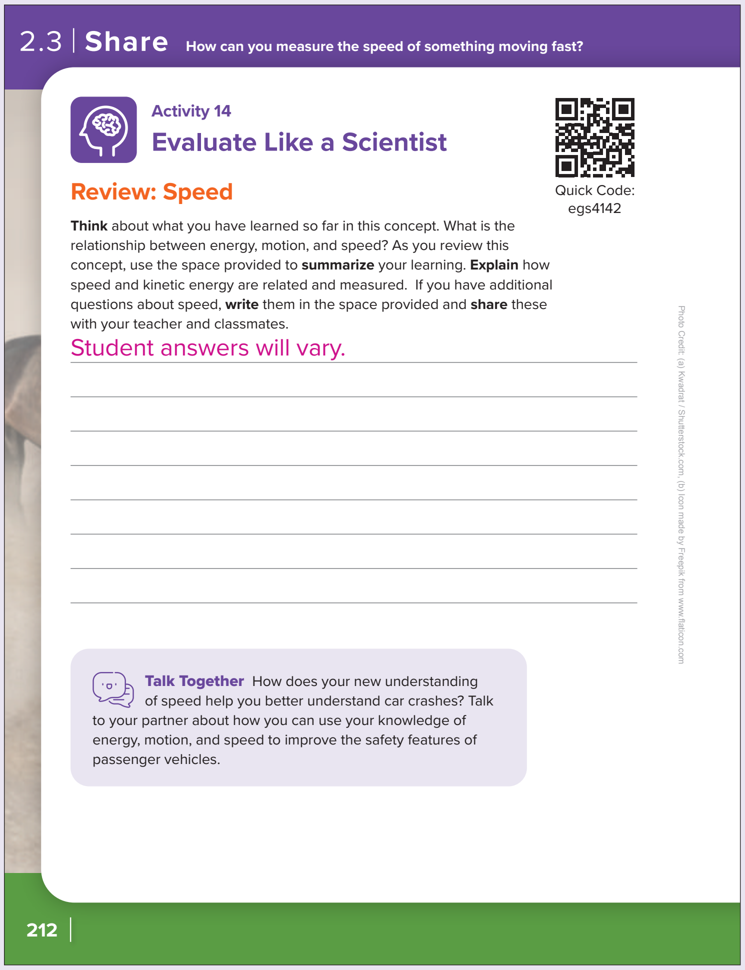

2.3 | **Share** How can you measure the speed of something moving fast?

Activity 14

Evaluate Like a Scientist

Quick Code: egs4142

Review: Speed

Think about what you have learned so far in this concept. What is the relationship between energy, motion, and speed? As you review this concept, use the space provided to **summarize** your learning. **Explain** how speed and kinetic energy are related and measured. If you have additional questions about speed, **write** them in the space provided and **share** these with your teacher and classmates.

Student answers will vary.

Talk Together How does your new understanding of speed help you better understand car crashes? Talk to your partner about how you can use your knowledge of energy, motion, and speed to improve the safety features of passenger vehicles.

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DIGITAL

Quick Code:
egst4142

Lesson 6, *continued*

Review and Assess

Activity 14

Evaluate Like a Scientist

20 min

Review: Speed

Purpose

The final activity of the concept asks students to review and explain the main ideas of speed. This activity allows students to reflect on what they understand about speed and how it relates to the overall unit project, focusing on vehicle safety.

Instructional Focus

In this activity, students summarize their learning and apply it to the big ideas of the unit.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas from their notes. You may also share the summative assessment for this concept with students.

In the summative concept assessment, students will identify how speed is measured and what impact an increase in force has on the speed of an object. Students will also identify the relationship between speed and the time it takes to travel a distance.

Teacher Reflection

- How many of my students met the objectives for this concept?
- For students who did not meet the objectives, what are my next steps?

CONCEPT 2.4

Energy and Collisions

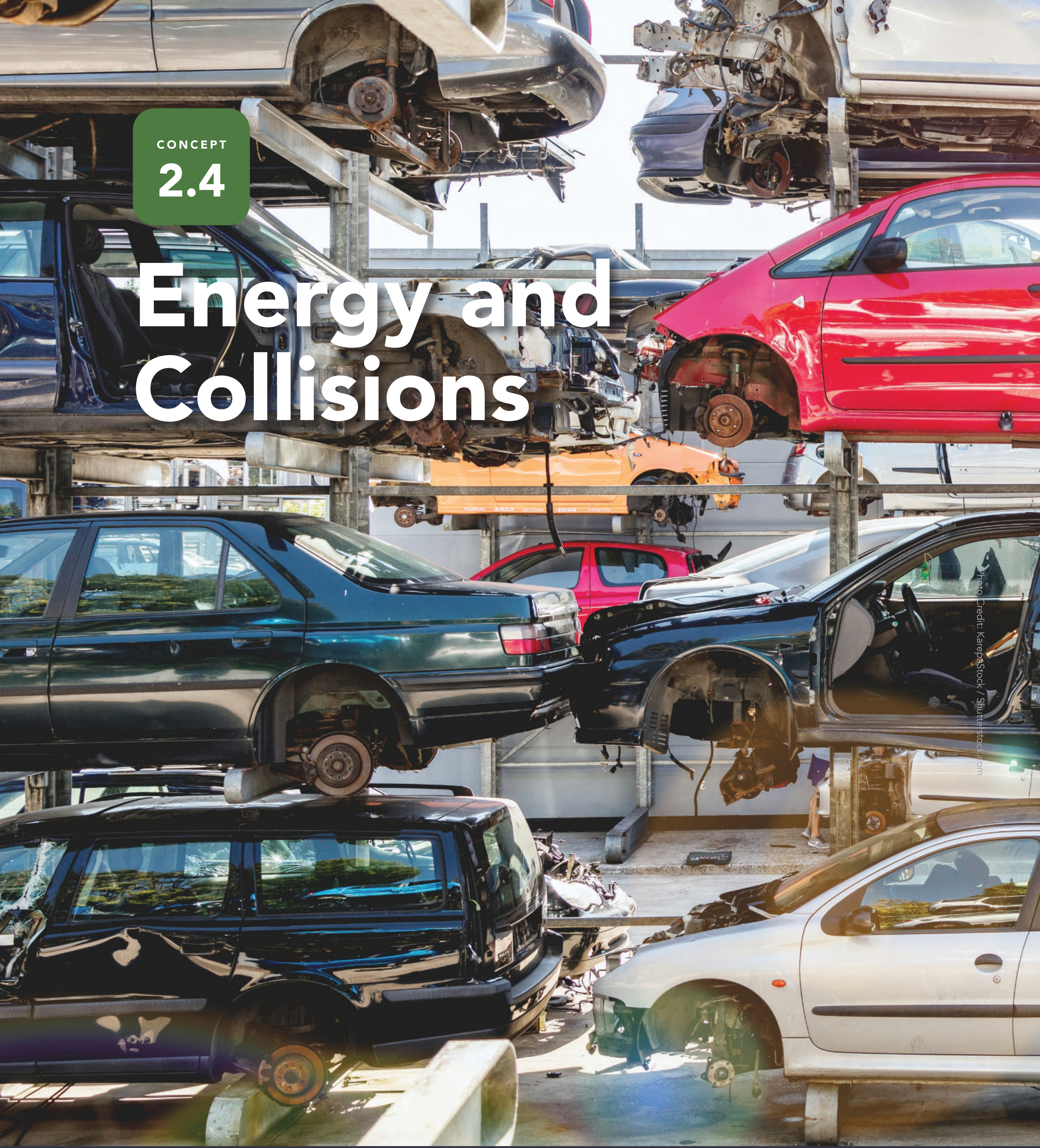


Photo Credit: KarepaStock / Shutterstock.com

Concept Objectives

By the end of this concept, students should be able to:

- Construct an explanation based on evidence and logical reasoning that the speed of an object depends on the energy of the object.
- Analyze and interpret data to describe how the speeds of objects and masses of objects affect the amount of damage in collisions between objects.
- Predict the outcomes of collisions based on patterns in energy transfer and change between the interacting objects.
- Use mathematical and computational thinking to organize data to reveal patterns in the mass, speed, and energy of objects using standard units.

Quick Code:
egst4143

Key Vocabulary

new: collision, mass

review: energy, force, kinetic energy, speed

Quick Code:
egst4144

Key Vocabulary Strategies

Guess the Word

Select the vocabulary words to introduce, divide the class into small teams, and assign a word to them without revealing it to the rest of the class. Provide the teams with a list of interview questions about their word and have them prepare the answers. Then, be the interviewer and ask the questions to the corresponding team. Finally, have the rest of the class guess their assigned word.

Word ID

Ask students to create an "identity card" for each word. On each card, they should write the word, its definition, an example, and a sketch. Then, have each student share the ID card with a partner.

Concept Pacing

Recommended Pathway

In order to meet the expectations of the standards, students must complete each activity within the recommended pathway.

Location	Days	Model Lesson	Time
Wonder	Lesson 1	Activity 1	10 min
		Activity 2	15 min
		Activity 3	20 min
Learn	Lesson 2	Activity 4	20 min
		Activity 5	25 min
	Lesson 3	Activity 6	30 min
		Activity 7	15 min
	Lesson 4	Activity 8	45 min
	Lesson 5	Activity 9	20 min
Share		Activity 10	25 min
	Lesson 6	Activity 11	20 min
		Activity 12	25 min

Content Background

Throughout the unit, students have learned how to describe, quantify, calculate, and investigate how objects in the world move around them. Students explored the relationships between complex ideas like energy, work, and force. They have applied these concepts to include interactions with speed and slope. Now, students apply what they understand about the physics of motion and energy transfer to explain what happens when objects collide. Students investigate how the variables of mass and speed are connected to the force of an impact.

In this concept, students explore real-world scenarios that provide evidence in support of Newton's laws. Students do not need to memorize nor cite the laws. Instead, by the end of this concept, students should have a basic understanding of the underlying principles. Students should be able to explain the outcomes of their investigations in a way that demonstrates comprehension of how these laws include all of the material covered in Unit 2.

In the Unit Project that follows this concept, students design an automobile safety feature that reflects their understanding of how the principles of the laws of motion can be leveraged to engineer products that keep passengers in a car safe.

The following information is provided for teacher reference only.

Sir Isaac Newton published his first law of motion in 1687. Newton's Laws of Motion, used as a framework for this concept, state the following:

- Newton's First Law of Motion: An object is in motion when its distance from another object is changing. This law, also known as the law of inertia, states that an object in uniform motion remains that way unless an external force is applied.
- Newton's Second Law of Motion: Newton's second law explains the relationship between force (F), mass (m), and acceleration (a). It states that force is equal to a change in momentum per change in time, written in mathematical form as F=ma.
- Newton's Third Law of Motion: Newton's third law states that for every action (force), there is an equal and opposite reaction (force). For example, when an athlete jumps to catch a ball, his feet push down on the ground (action), and the ground pushes the athlete into the air (reaction).

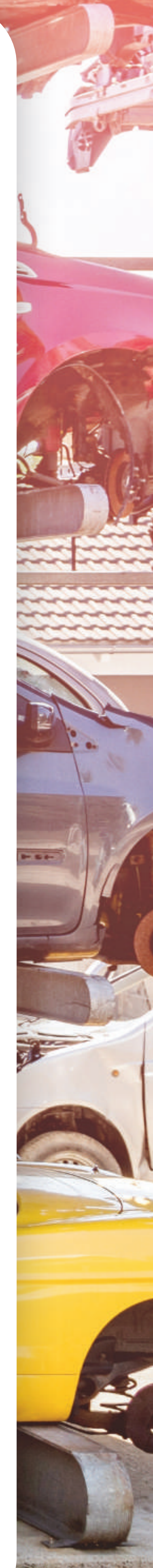
The physics behind Newton's Laws of Motion will be explored in a more comprehensive manner in later grades.

Hands-On Investigations Preparation

Learn

Location	Instructional Focus
Activity 6: Speed and Collisions	In this activity, students build on their understanding of speed from the previous concept's Hands-On Investigation: Racing Downhill.
Optional Extension: Activity 8: Mass in Collisions	In this optional extension activity, students will engage in two Hands-On Investigations to explore the relationships between speed, mass, and kinetic energy. During the investigations, students will use evidence obtained to engage in arguments about the relationship between the mass and both the speed and kinetic energy of objects.

	Materials to Prepare (per group)
	• Modeling clay or flour mixture • Piece of cardboard • Meterstick
	Part 1 • Toy car • Scale or balance • Metal washers, paper clips, coins, paper • Books • Ramp from cardboard • Tape • Stopwatch • Meterstick **Part 2** • 1-meter string • Paper cup or milk carton • Toy car or light and heavy objects found in the classroom • Ruler



Lesson 1

Activity 1
Can You Explain?

10 min

What happens to objects when they collide with another object?

Purpose

The last concept opens with the idea of objects colliding, so that students can connect the ideas of energy, force, and speed to the Unit Project context of a car crash. Students may have experience with a wrecking ball, but also encourage students to think of other examples of collisions to activate their prior knowledge.

Instructional Focus

In this activity, students begin to construct explanations about what happens to energy during collisions.

Life Skills **Endurance**

Strategy

Ask students to share if they have ever seen a building being knocked down using a wrecking ball, such as the one shown in the image. If they have not, ask students to look at the picture of the wrecking ball and imagine it knocking down the wall.

Encourage students to explain what they know about how energy relates to the speed of an object, such as the speed of a moving, heavy ball. Encourage students to use the terms previously discussed, such as potential and kinetic energy.

Then, ask students to consider what happens when the ball hits the wall. Challenge students to think about the change in speed for two objects colliding with each other and what the change in speed indicates about the energy in the system. Students may have some initial ideas about how to answer the question. At this point, a fully formed or completely scientifically accurate explanation is not necessary. However, by the end of the concept, students should be able to construct a scientific explanation, which includes evidence from the concept activities.

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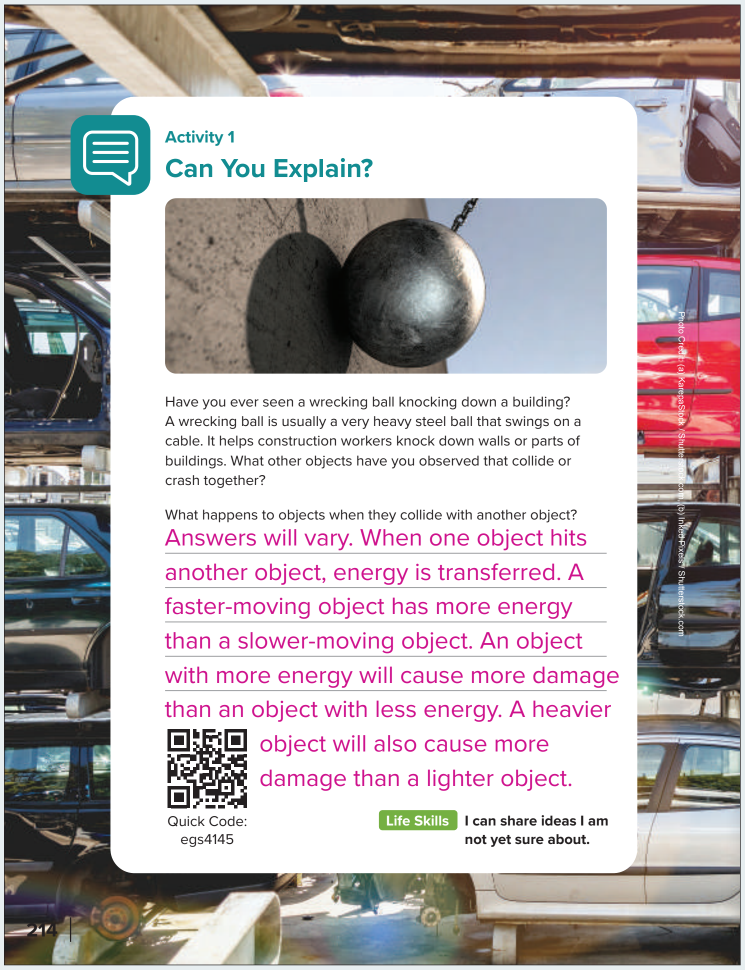

Activity 1
Can You Explain?

Have you ever seen a wrecking ball knocking down a building? A wrecking ball is usually a very heavy steel ball that swings on a cable. It helps construction workers knock down walls or parts of buildings. What other objects have you observed that collide or crash together?

What happens to objects when they collide with another object?

Answers will vary. When one object hits another object, energy is transferred. A faster-moving object has more energy than a slower-moving object. An object with more energy will cause more damage than an object with less energy. A heavier object will also cause more damage than a lighter object.

Quick Code: egs4145

Life Skills I can share ideas I am not yet sure about.

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Activity 1
Can You Explain?

Quick Code: egst4145

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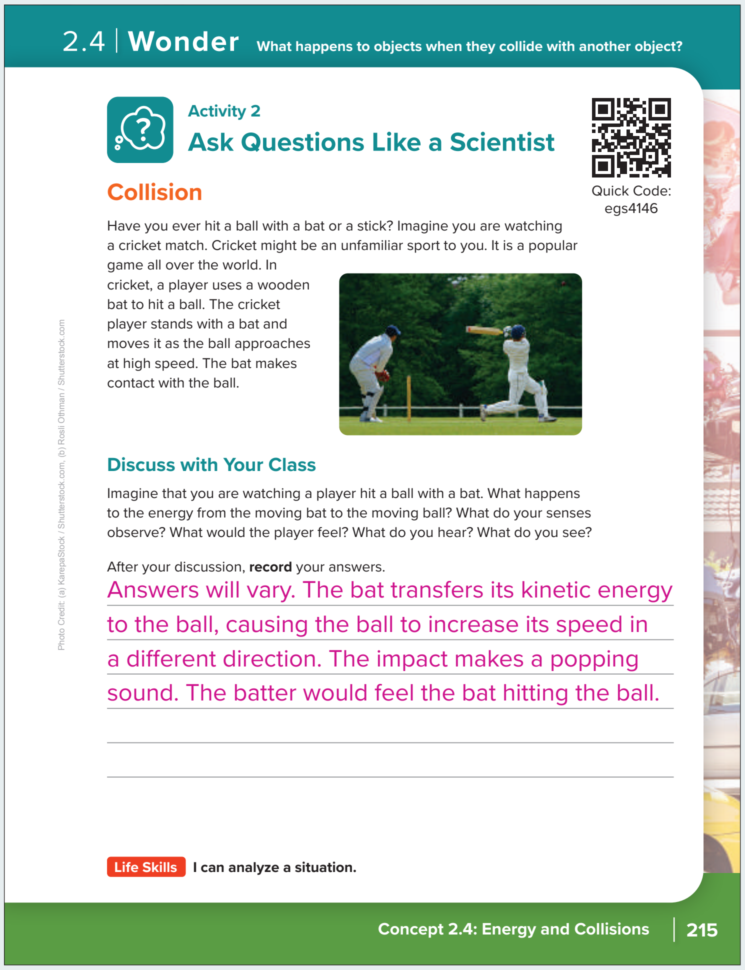

2.4 | Wonder What happens to objects when they collide with another object?

Activity 2

Ask Questions Like a Scientist

Quick Code: egs4146

Collision

Have you ever hit a ball with a bat or a stick? Imagine you are watching a cricket match. Cricket might be an unfamiliar sport to you. It is a popular game all over the world. In cricket, a player uses a wooden bat to hit a ball. The cricket player stands with a bat and moves it as the ball approaches at high speed. The bat makes contact with the ball.

Discuss with Your Class

Imagine that you are watching a player hit a ball with a bat. What happens to the energy from the moving bat to the moving ball? What do your senses observe? What would the player feel? What do you hear? What do you see?

After your discussion, **record** your answers.

Answers will vary. The bat transfers its kinetic energy to the ball, causing the ball to increase its speed in a different direction. The impact makes a popping sound. The batter would feel the bat hitting the ball.

Life Skills I can analyze a situation.

Concept 2.4: Energy and Collisions | 215

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Activity 2

Ask Questions Like a Scientist

Collision

Quick Code: egst4146

Photo Credit: Rosli Othman / Shutterstock.com

Investigative Phenomenon

Activity 2

Ask Questions Like a Scientist

15 min

Collision

Purpose

Most students have some familiarity with hitting a ball with a bat or a stick. In order to understand the forces involved in a car crash, students examine the forces between a bat and a ball. This activity encourages students to use their understanding of potential and kinetic energy and apply it to what happens when a bat makes contact with a ball.

Instructional Focus

In this activity, students examine the game of cricket, make observations, and ask questions about changing variables in the ball and bat system.

Life Skills **Decision-Making**

Strategy

While cricket may be unfamiliar to many students, it is a globally popular sport. Students may also have heard of or seen American-style baseball or softball, which are similar examples. A cricket or baseball bat is not necessary to understand the idea of two objects colliding. Use this cricket scenario to initiate small-group or class discussion about the different things that happen when objects collide.

Lesson 1, *continued*

Consider taking students and a bat and ball outside to observe what happens when bat and ball collide. Encourage students to make very detailed observations about what happens during and after the collision of ball and bat. Repeat several times so that all students can see. (If it is not possible to take students and the sporting equipment outside, you may want to play a clip of a cricket, baseball, or softball match for students to support visualization and observation.)

Discuss with Your Class

Use students' ideas and observations to generate discussion about collisions. Then, provide different scenarios of other collisions and have students make predictions about what they think they would observe. For example, what would they observe if a stuntperson jumped out of a window onto an airbag or if a stone hit a glass window?

Finally, have students generate questions about the cricket situation based on changing the variables in the image. Some students may need to be guided toward the variables of speed of ball, mass of ball, mass of bat, and speed of bat.

Teacher Reflection

- Did this activity engage the students?
- Did this activity allow students to generate their own questions?
- What, if anything, about this activity would I do differently next time?
- Were students able to make predictions about what they would observe during different types of collisions?

Photo Credit: Sony Ho / Shutterstock.com

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2.4 | **Wonder** What happens to objects when they collide with another object?

Activity 3

Observe Like a Scientist

Quick Code: egs4147

Watching Objects Collide

Have you ever made toy cars crash into each other? Think about happened when they crashed. What safety equipment keeps us safe in our cars? **Read** the text and **watch** the video, if available. **Write** three questions you have, and **share** them with the class.

Video

What happens to your body when you ride in a car and the car stops suddenly? Your body continues to move forward. Objects that are in motion stay in motion until something stops them. When the car stops suddenly, what keeps you in your place? Seatbelts are used in cars to keep your body from moving forward. Seatbelts have saved thousands of lives.

Airbags slow the speed of a person moving forward. An airbag is like a big pillow to land against during a crash. Airbags inflate automatically when sensors in the car detect a crash. The purpose of an airbag is to absorb the energy of the car's impact. Airbags are made of thin, nylon material folded into the steering wheel, seat, dashboard, or door. A sensor tells the airbag to inflate. The airbag fills with a gas to provide a soft cushion. An airbag has to deflate almost as fast as it inflates. Airbags have holes, or vents, to allow the bag to deflate so you can get out of the car.

Photo Credit: (a) KarepaStock / Shutterstock.com, (b) Sony Ho / Shutterstock.com

Life Skills I can identify problems.

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Activity 3

Observe Like a Scientist

Watching Objects Collide

Quick Code: egst4147

Activate Prior Knowledge

Activity 3

Observe Like a Scientist

20 min

Watching Objects Collide

Purpose

Students should recall investigating the speed of fast objects, such as a train, in the previous concept. In this activity, students observe a real-world example of a train collision. As students observe the use of an airbag on a train, encourage students to also consider how an airbag in a car keeps people safe from the forces in a collision.

Instructional Focus

In this activity, students obtain evidence from text and media to explain the cause-and-effect relationship between collisions and transfer, or change, of energy. Students also examine the role of airbags in keeping passengers safe.

Life Skills **Critical Thinking**

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Use the reading passage and video to help explain the effects of a collision and the role of airbags in keeping passengers safe.

Lesson 1, *continued*

Prepare students for reading the text and watching the video by asking the following:

ASK

- *What parts of a car help keep you safe in a collision?*
- *What is an airbag?*
- *How does an airbag keep you safe in a car?*
- *Predict what would happen if a train collided with a car.*

Read the text and watch the video *Train versus Car*, if available.

Ask students to generate their own questions from the text and video related to how passengers are protected during a collision. Encourage students to focus their questions around: *What happens in a collision? What can safety equipment do to protect me? How does the size of objects affect what happens in a collision?*

After reading the text and watching the video, facilitate a discussion where students use evidence from the video and text to explain how airbags can reduce the effects of a collision. During the discussion, encourage students to ask each other questions such as: *How do you know? Do you have additional evidence?*

Note: Be sensitive to students in your class who have been in a car crash or had family members in a car crash. This could be an emotional topic.

Differentiation

APPROACHING LEARNERS

Have students think of times when they have collided with another object. For example, a student bumped into another student walking in the hallway. What happened to the direction and speed of each person involved? Another example is toy cars or marbles. Have students discuss these examples using vocabulary from this unit.

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Every year, there are many accidents in which a train hits a car that may be stuck on the train tracks. Trains are much larger than cars. Trains can travel at a high speed. The higher the force when objects collide, the more dangerous it is. Could airbags on the front of a train help protect people in a car?

I wonder . . .

Student questions will vary. Which way do objects move when one object hits another?

I wonder . . .

Does the frame of a car protect me in a collision?

I wonder . . .

Do larger objects that are heavier cause more damage in a collision?

Concept 2.4: Energy and Collisions | 217

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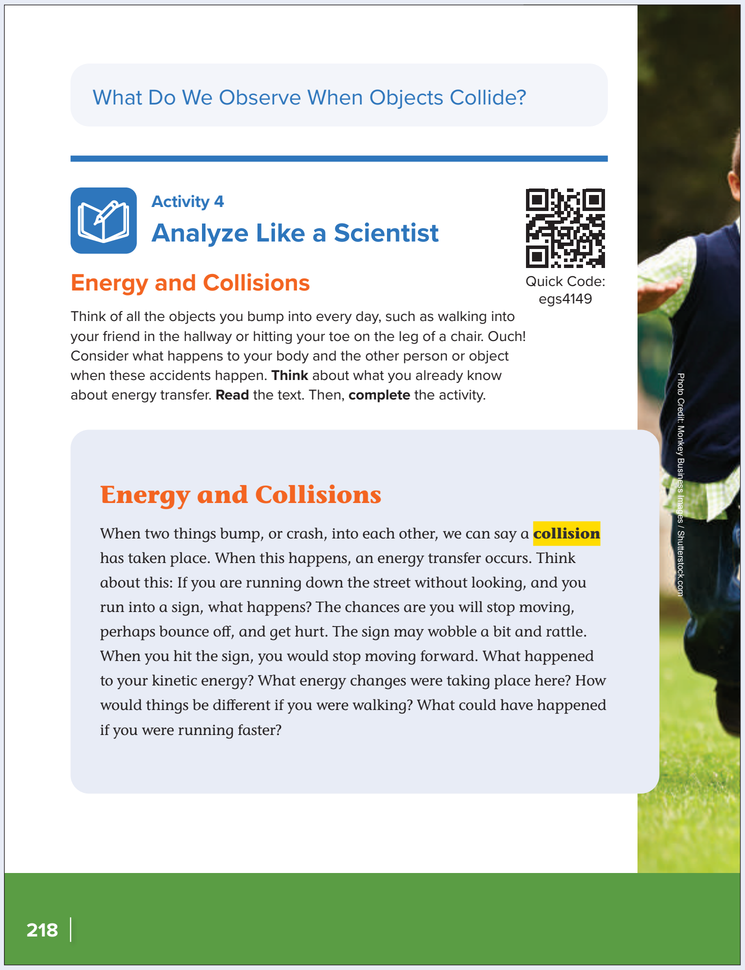

What Do We Observe When Objects Collide?

Activity 4
Analyze Like a Scientist

Quick Code:
egs4149

Energy and Collisions

Think of all the objects you bump into every day, such as walking into your friend in the hallway or hitting your toe on the leg of a chair. Ouch! Consider what happens to your body and the other person or object when these accidents happen. **Think** about what you already know about energy transfer. **Read** the text. Then, **complete** the activity.

Energy and Collisions

When two things bump, or crash, into each other, we can say a **collision** has taken place. When this happens, an energy transfer occurs. Think about this: If you are running down the street without looking, and you run into a sign, what happens? The chances are you will stop moving, perhaps bounce off, and get hurt. The sign may wobble a bit and rattle. When you hit the sign, you would stop moving forward. What happened to your kinetic energy? What energy changes were taking place here? How would things be different if you were walking? What could have happened if you were running faster?

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Activity 4
Analyze Like a Scientist
Energy and Collisions

Quick Code:
egst4149

Lesson 2

What Do We Observe When Objects Collide?

Activity 4
Analyze Like a Scientist

20 min

Energy and Collisions

Purpose

As a starting point for exploring the variables involved in the collision of two objects, this activity invites students to consider everyday scenarios involving small-scale collisions. Thinking about the transfer of kinetic energy from their body to objects they might commonly bump into can help students begin to understand how larger objects, moving at higher speeds, can respond more dramatically.

Instructional Focus

Students obtain information from a text to draw a model describing how the kinetic energy of colliding objects changes before and after a collision.

Strategy

Have students read the text that describes how the differences in the kinetic energy of objects can determine the forces exerted in a collision. The emphasis of this concept is on the transfer of energy in the collision and how the amount of energy transferred depends in part on object speed and mass.

ASK *What happens to energy when two objects collide?*

Lesson 2, *continued*

Facilitate a discussion on the reading passage, encouraging students to react to and connect personal experiences with the text. Then, instruct students to draw a two-framed comic strip showing the before and after of a collision of their choosing. Students write a description of the changes in kinetic energy below the illustrations.

Sample student answer: The bicycle has kinetic energy as it goes down the sidewalk. When the cyclist collides with the bread cart, the kinetic energy transfers to the cart and the bread. The cart tips over and the bread scatters.

Differentiation

APPROACHING LEARNERS

This activity contains several new vocabulary terms that may be unfamiliar to students. After reading, have students draw a collision and label all the parts using the highlighted vocabulary words from the reading passage. Have students compare their diagrams with a partner and correct any misconceptions.

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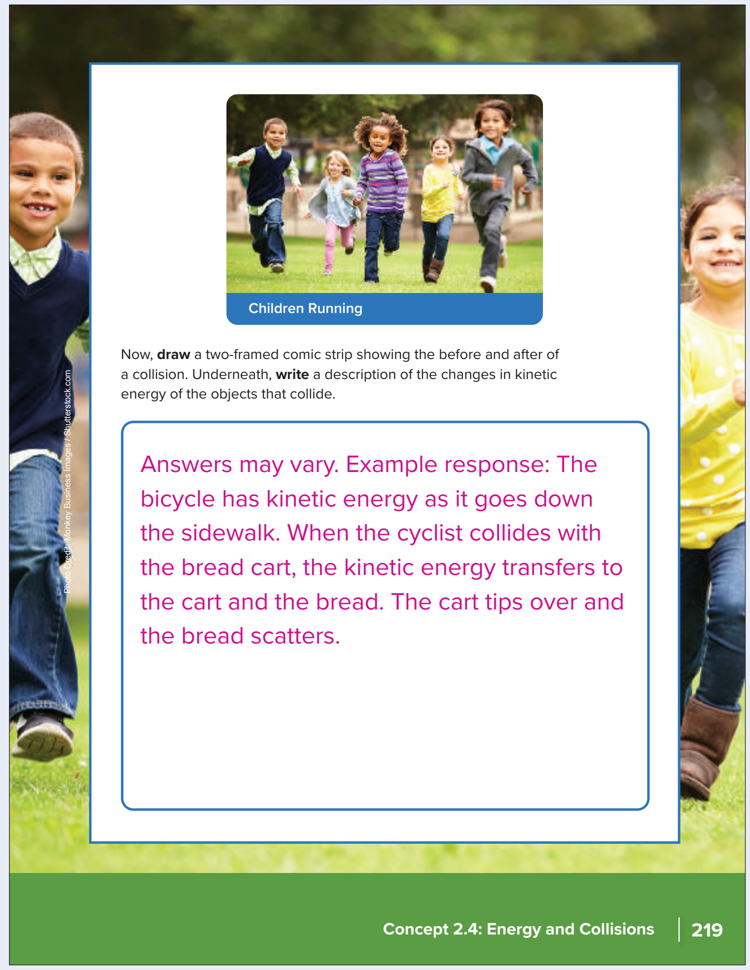

Children Running

Now, **draw** a two-framed comic strip showing the before and after of a collision. Underneath, **write** a description of the changes in kinetic energy of the objects that collide.

Answers may vary. Example response: The bicycle has kinetic energy as it goes down the sidewalk. When the cyclist collides with the bread cart, the kinetic energy transfers to the cart and the bread. The cart tips over and the bread scatters.

Concept 2.4: Energy and Collisions | 219

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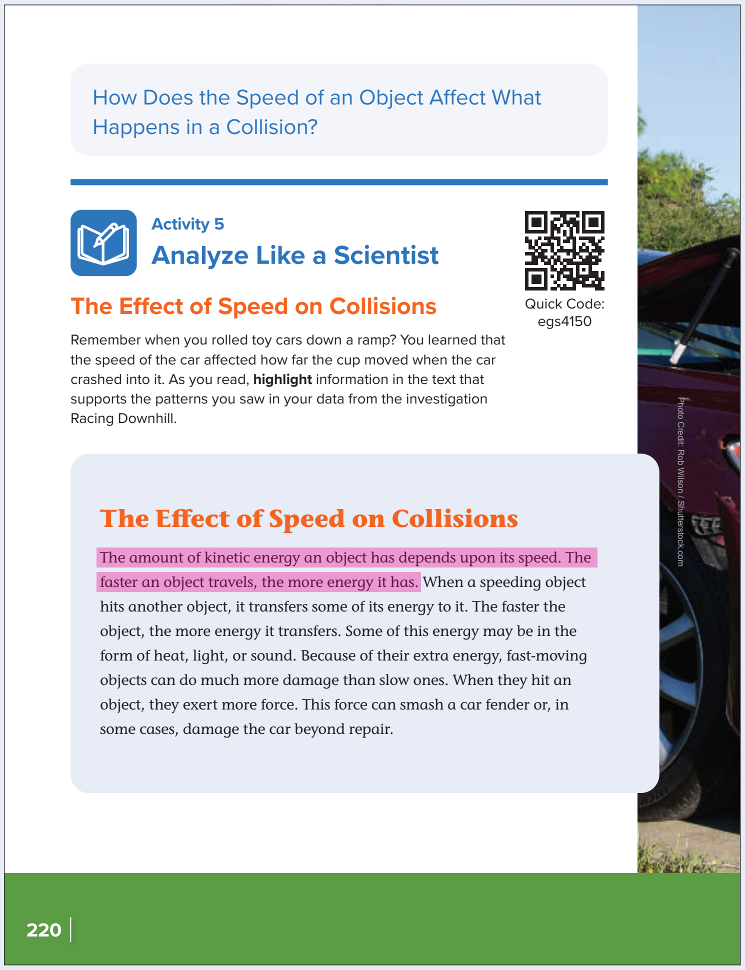

How Does the Speed of an Object Affect What Happens in a Collision?

Activity 5

Analyze Like a Scientist

The Effect of Speed on Collisions

Quick Code: egs4150

Remember when you rolled toy cars down a ramp? You learned that the speed of the car affected how far the cup moved when the car crashed into it. As you read, **highlight** information in the text that supports the patterns you saw in your data from the investigation Racing Downhill.

The Effect of Speed on Collisions

The amount of kinetic energy an object has depends upon its speed. The faster an object travels, the more energy it has. When a speeding object hits another object, it transfers some of its energy to it. The faster the object, the more energy it transfers. Some of this energy may be in the form of heat, light, or sound. Because of their extra energy, fast-moving objects can do much more damage than slow ones. When they hit an object, they exert more force. This force can smash a car fender or, in some cases, damage the car beyond repair.

Photo Credit: Rob Wilson / Shutterstock.com

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Photo Credit: Rob Wilson / Shutterstock.com

DIGITAL

Activity 5

Analyze Like a Scientist

The Effect of Speed on Collisions

Quick Code: egst4150

How Does the Speed of an Object Affect What Happens in a Collision?

Activity 5

Analyze Like a Scientist

25 min

The Effect of Speed on Collisions

Purpose

Students apply what they already know about speed and energy to consider the effects of these factors on collisions. Asking students to recall a previous activity where they gathered data helps them to connect what they have already learned with new information.

Instructional Focus

In this activity, students use a text to analyze and look for patterns in kinetic energy and speed data collected in the Hands-On Investigation: Racing Downhill.

Strategy

Ask students to review their own data (or provide students with sample data) from the Hands-On Investigation: Racing Downhill, which they conducted in the previous concept. In that activity, students used model cars to measure the speed and kinetic energy of objects moving down inclines of various angles.

Instruct students to read the text describing the effects of speed on a collision.

Tell students to highlight information in the text that supports the patterns they see in the data.

Lesson 2, *continued*

With a partner, have students make predictions about collisions by answering the questions at the end of the text. Have students share out to see how their thinking compares to others. Accept all answers at this time.

ASK *What does the pattern of data you see allow you to conclude about kinetic energy and speed?*
Answers will vary. Objects that have more kinetic energy travel at a faster speed.

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Accident

If a car increases its speed, its kinetic energy increases. All this energy will result in a large force being exerted in an accident. This is one reason why driving fast is so hazardous. If two cars drive headlong into one another, then the forces exerted in the accident depend upon the combined speed of both cars. Damage would be much more severe. What do you think would happen if two cars traveling at different speeds in the same direction collided? How would the forces in this rear-end collision compare to those in a headlong collision?

Concept 2.4: Energy and Collisions | 221

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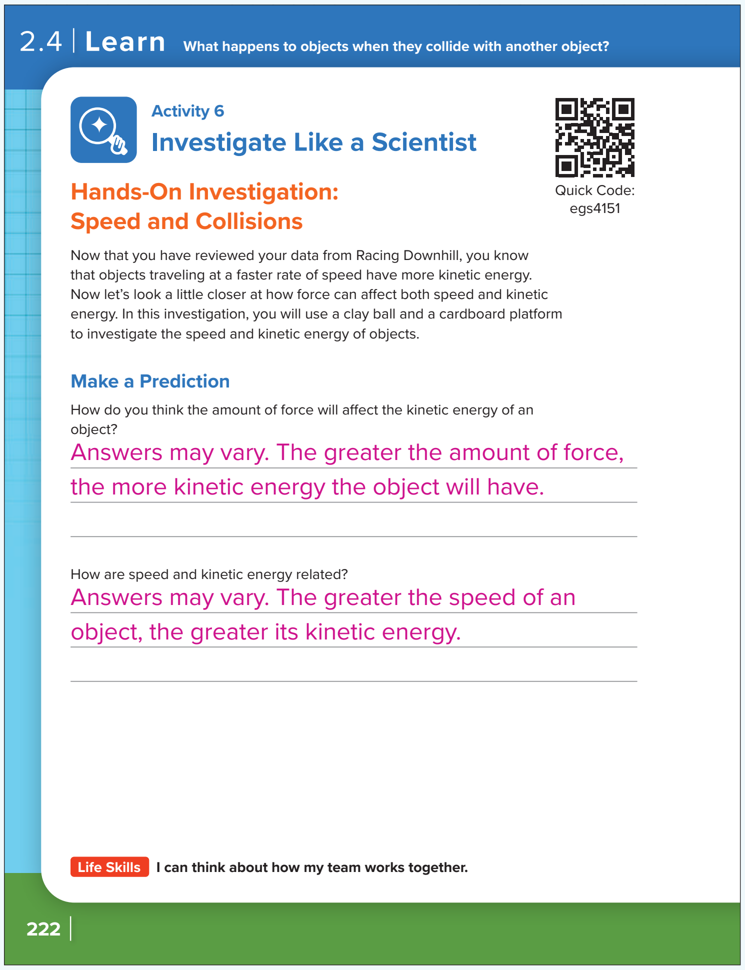
2.4 | **Learn** What happens to objects when they collide with another object?

Activity 6
Investigate Like a Scientist

Quick Code: egs4151

Hands-On Investigation: Speed and Collisions

Now that you have reviewed your data from Racing Downhill, you know that objects traveling at a faster rate of speed have more kinetic energy. Now let's look a little closer at how force can affect both speed and kinetic energy. In this investigation, you will use a clay ball and a cardboard platform to investigate the speed and kinetic energy of objects.

Make a Prediction

How do you think the amount of force will affect the kinetic energy of an object?

Answers may vary. The greater the amount of force, the more kinetic energy the object will have.

How are speed and kinetic energy related?

Answers may vary. The greater the speed of an object, the greater its kinetic energy.

Life Skills I can think about how my team works together.

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DIGITAL

Activity 6
Investigate Like a Scientist
Hands-On Investigation:
Speed and Collisions

Quick Code:
egst4151

Lesson 3

Activity 6
Investigate Like a Scientist

30 min

Hands-On Investigation: Speed and Collisions

Purpose
In this investigation, students deepen their understanding of force and speed by investigating how these factors affect the amount of kinetic energy transferred in a collision.

Instructional Focus
In this activity, students build on their understanding of speed from the previous concept's Hands-On Investigation: Racing Downhill.

Life Skills **Collaboration**

Lesson 3, *continued*

Activity Activator: Make a Prediction

In this activity, students use a piece of cardboard and a ball of clay to measure the kinetic energy of faster and slower objects. Students will observe and assess the damage made to a ball of clay when the ball of clay is lightly dropped versus when the ball is thrown harder and faster onto a landing platform.

To introduce the activity, remind students of the experiments they performed in Racing Downhill that illustrated how more speed equals more force in a moving object. Ask students what happens when a moving car hits an unmoving object. Tell students that they will be dropping and throwing a ball of clay onto a piece of cardboard that will serve as a landing platform. They will observe the damage made to the clay and record sketches in the table provided.

Materials List (per group)

- Modeling clay or flour mixture
- Piece of cardboard
- Meterstick

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Follow proper disposal and cleaning procedures after the lab.
- Wear proper safety attire, including closed-toe shoes, safety goggles, lab coats or aprons, and gloves.
- Tie back long hair.
- Do not eat or drink anything in the lab.

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What materials do you need? (per group)

- Modeling clay or flour mixture
- Piece of cardboard
- Meterstick

HANDS-ON INVESTIGATION

What Will You Do?

1. Roll a ball of clay in your hands, smoothing the sides of it. Sketch the ball of clay.
2. Use the cardboard to create a landing platform, attached to a hard surface on the ground. Position the clay ball 1 meter above the platform and lightly open your fingers to drop, not throw, the ball of clay onto the platform.
3. Sketch the dropped ball of clay in the table.
4. Smooth the clay ball over and repeat the experiment, this time putting force behind the clay ball and throwing it at the platform from 1 meter above. Sketch the result.
5. Repeat one more time and throw the clay ball a bit harder at the platform. Sketch the result.

Amount of Force Used	Sketch of Clay
Dropped	
Thrown Lightly	
Thrown Hard	

Concept 2.4: Energy and Collisions | 223

Lesson 3, *continued*

Activity Procedure: What Will You Do?

Measuring Kinetic Energy in Collisions

Inform students that they will be testing how the ball of clay's kinetic energy changes as the speed it is falling changes.

1. Have students roll a ball of clay in their hands, smoothing the sides of it.
2. Direct students to choose an area on the ground that is a hard surface to attach their cardboard. This will create a landing platform for their clay. Then, have another student position the clay ball 1 meter above the platform and lightly open their fingers to drop, not throw, the ball of clay onto the platform.
3. Ask students to carefully pick up the clay ball from the landing surface. Instruct students to make sketches of the ball in the data table. Their drawings should reflect any changes to the clay made by the impact.
4. Students will then smooth the clay ball over and perform the experiment two more times, each time putting a bit more force behind the clay ball and throwing it at the platform from 1 meter above.

Lesson 3, *continued*

Analysis and Conclusions: Think About the Activity

ASK

- *What can you conclude about the relationship between speed and kinetic energy based on this experiment?*
  Students should conclude that the greater the speed of a moving object, the greater the kinetic energy in the collision.
- *How do the results from this experiment compare with the results from the tests you did in Racing Downhill? How are they different?*
  Students may respond that when the stack of books was higher, the car went farther. When the ball of clay was dropped with more force, the dent was deeper.
- *What does the damage to the clay tell you about what happens to vehicles in a real-world collision?*
  Students should conclude that if a vehicle hits with greater force, the damage will be greater.

After students have analyzed their data and answered the analysis and conclusion questions, remind them of the investigative phenomenon of hitting a cricket ball.

ASK *Using evidence from your investigation, what would you expect to see if the bat is swung faster?*
The faster clay ball, the one thrown with more force, made a larger dent. Therefore, I think a faster swing will make the ball go farther.

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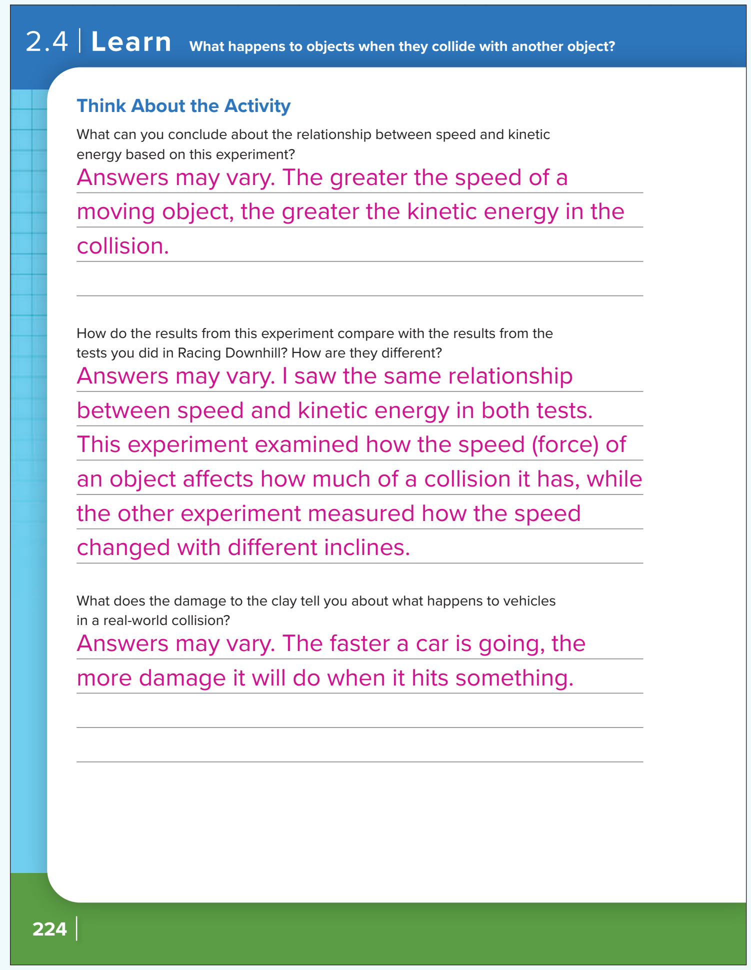
2.4 | Learn What happens to objects when they collide with another object?

Think About the Activity

What can you conclude about the relationship between speed and kinetic energy based on this experiment?

Answers may vary. The greater the speed of a moving object, the greater the kinetic energy in the collision.

How do the results from this experiment compare with the results from the tests you did in Racing Downhill? How are they different?

Answers may vary. I saw the same relationship between speed and kinetic energy in both tests. This experiment examined how the speed (force) of an object affects how much of a collision it has, while the other experiment measured how the speed changed with different inclines.

What does the damage to the clay tell you about what happens to vehicles in a real-world collision?

Answers may vary. The faster a car is going, the more damage it will do when it hits something.

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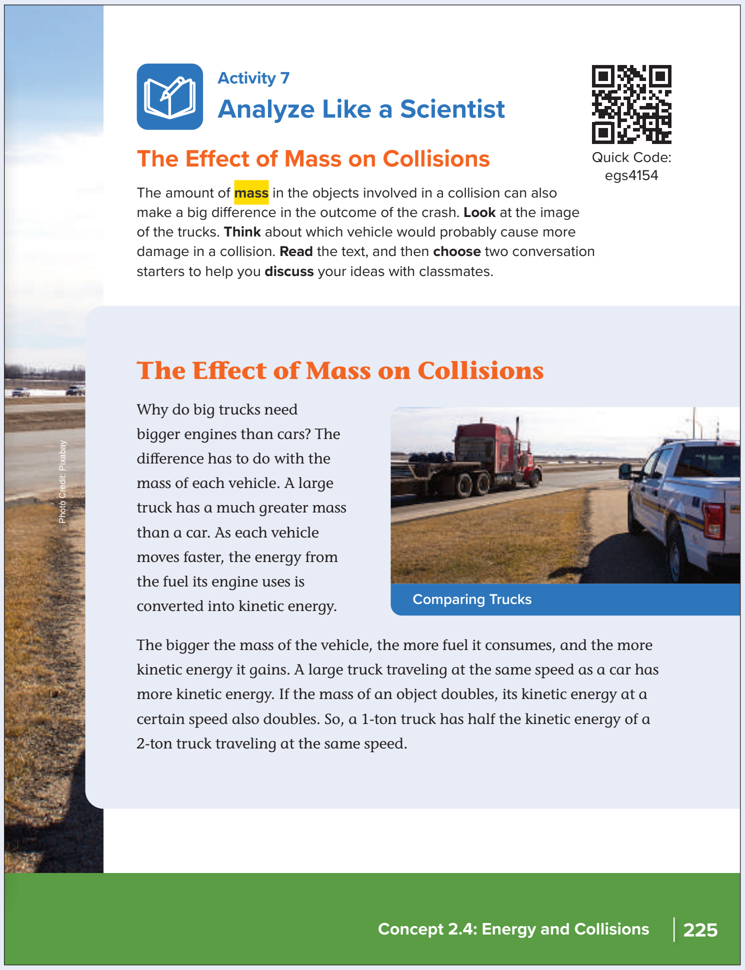

Activity 7

Analyze Like a Scientist

The Effect of Mass on Collisions

Quick Code: egs4154

The amount of mass in the objects involved in a collision can also make a big difference in the outcome of the crash. **Look** at the image of the trucks. **Think** about which vehicle would probably cause more damage in a collision. **Read** the text, and then **choose** two conversation starters to help you **discuss** your ideas with classmates.

The Effect of Mass on Collisions

Why do big trucks need bigger engines than cars? The difference has to do with the mass of each vehicle. A large truck has a much greater mass than a car. As each vehicle moves faster, the energy from the fuel its engine uses is converted into kinetic energy.

Photo Credit: Pixabay

Comparing Trucks

The bigger the mass of the vehicle, the more fuel it consumes, and the more kinetic energy it gains. A large truck traveling at the same speed as a car has more kinetic energy. If the mass of an object doubles, its kinetic energy at a certain speed also doubles. So, a 1-ton truck has half the kinetic energy of a 2-ton truck traveling at the same speed.

Concept 2.4: Energy and Collisions | 225

Photo Credit: Pixabay

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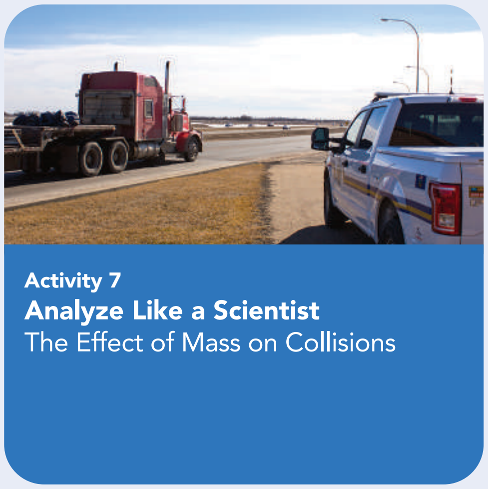

Quick Code:
egst4154

Activity 7

Analyze Like a Scientist

15 min

The Effect of Mass on Collisions

Purpose

Students have explored the relationship between speed and the kinetic energy transfer in collisions. Mass is another variable that is important to understand in collisions. The reading passage in this activity provides students with background information that will prepare them for the investigation Mass in Collisions.

Instructional Focus

In this activity, students analyze a text to explain how the mass of moving objects can affect the amount of kinetic energy in a collision.

Strategy

To prepare students for the Hands-On Investigation: Mass in Collisions, ask students to think about what they already know about the role that mass plays in a collision. Pose the following scenario for students to consider.

Imagine that you are playing football with a group of family members. Throughout the course of the game, you might run into other players. If you bumped into your 2-year-old cousin, the impact to your body would feel very different than if you bumped into your adult uncle.

ASK *What is the main difference in the impact of these two collisions?*

Student answers will vary but could include: The toddler's body is smaller than the adult's body. The impact with the toddler probably would not knock me over. Bumping into the adult, who is much bigger, might knock me down.

Next, have students read the text that describes how mass affects a collision.

Lesson 3, *continued*

Use the conversation starters to have groups of three discuss what they have read about collisions and mass. Each student should choose two starters to complete and then share with their group.

As students are discussing, circulate around the classroom to formatively assess students' understanding of the effect mass has on the kinetic energy of an object and the damage it can cause in a collision. Encourage group members to reply to each other's comments using the starters as well.

Conversation Starters

Question	Clarify	Connect
I don't get this part . . .	Let me explain . . .	This reminds me of . . .
What if . . .	No, I think it means . . .	The differences are . . .
Predict	**Comment**	**Explain**
I wonder if . . .	This is confusing because . . .	The basic idea is . . .
I think that . . .	This is hard because . . .	My understanding is . . .

Differentiation

ADVANCED LEARNERS

Bicyclists sometimes have collisions while riding or racing and can get concussions if they hit their heads. Have students research helmet technologies that help reduce the impact of collisions.

APPROACHING LEARNERS

In order to support students' discussions around mass and collisions, consider reviewing the glossary term *mass* to begin the lesson. Have students identify pairs of objects in the classroom where one object has more or less mass than the other.

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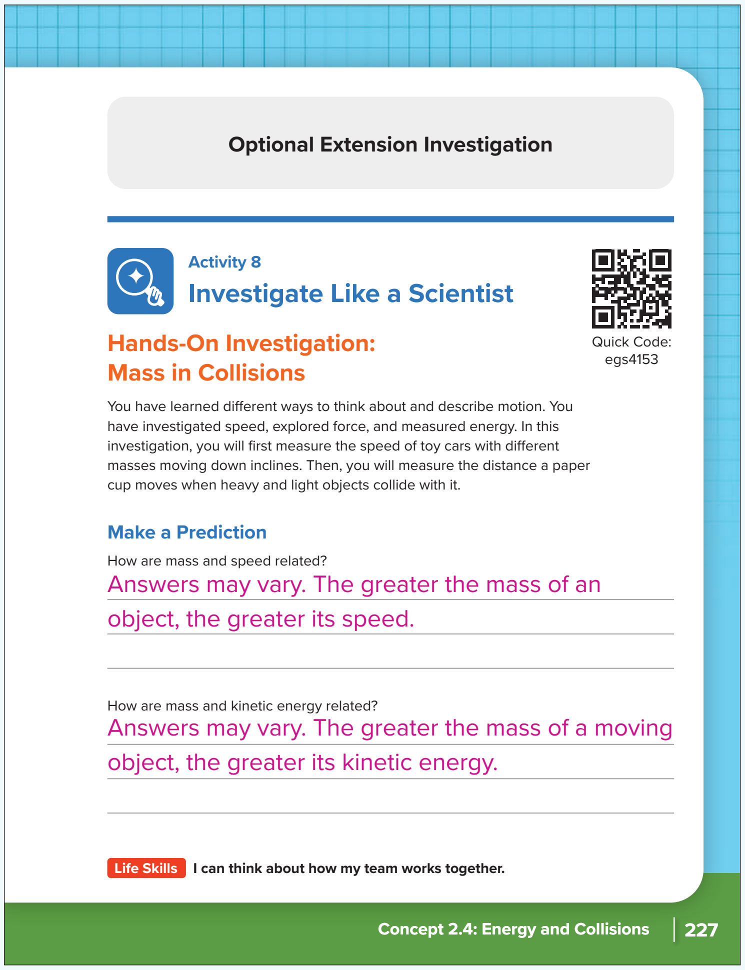
Optional Extension Investigation

Activity 8

Investigate Like a Scientist

Quick Code: egs4153

Hands-On Investigation: Mass in Collisions

You have learned different ways to think about and describe motion. You have investigated speed, explored force, and measured energy. In this investigation, you will first measure the speed of toy cars with different masses moving down inclines. Then, you will measure the distance a paper cup moves when heavy and light objects collide with it.

Make a Prediction

How are mass and speed related?

Answers may vary. The greater the mass of an object, the greater its speed.

How are mass and kinetic energy related?

Answers may vary. The greater the mass of a moving object, the greater its kinetic energy.

Life Skills I can think about how my team works together.

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Activity 8

Investigate Like a Scientist

Hands-On Investigation:
Mass in Collisions

Quick Code:
egst4153

Lesson 4

Optional Extension Investigation

Activity 8

Investigate Like a Scientist

45 min

Hands-On Investigation: Mass in Collisions

Purpose

The Unit Project asks students to assimilate knowledge they have gained to design a safety feature that would prevent injury during a collision. To prepare students for this task, in this activity students engage in two more Hands-On Investigations. These activities connect what students have learned about the concepts of force, speed, mass, kinetic energy with the role they play in the outcomes of a collision.

Instructional Focus

In this activity, students use evidence obtained to engage in arguments about the relationship between the mass and both the speed and kinetic energy of objects.

Life Skills **Collaboration**

Lesson 4, *continued*

Activity Activator: Make a Prediction

This activity builds on student knowledge from the Hands-On Investigatons Racing Downhill and Speed and Collisions. In the first activity, students will manipulate the mass of objects to measure the effect of increased mass on speed. In the second activity, students will investigate the effect that an increase in mass has on kinetic energy. To do this, students compare the distance a paper cup moves when light and heavy cars collide with it.

To introduce the activity, remind students of the experiments they performed in Racing Downhill and Speed and Collisions. Tell students they will now be investigating how mass affects kinetic energy in collisions. Connect this idea to real life by asking students if all vehicles they see on the road have the same or similar mass. Note examples to compare, such as compact cars (less mass) and trucks or buses (more mass). Ask students to plan how to test and measure the speed of toy cars with different masses. If needed, guide students to realize that they will need to measure the mass of the toy cars each time rather than the angle of incline.

Materials List (per group)

Part 1

- Toy car
- Scale or balance
- Metal washers, paper clips, coins, paper
- Books, 2
- Ramp from cardboard
- Tape
- Stopwatch
- Meterstick

Part 2

- 1-meter string
- Paper cup or milk carton
- Ruler
- Toy car or light and heavy objects found in the classroom

HANDS-ON INVESTIGATION

Safety

- Follow all lab safety guidelines.
- Follow proper disposal and cleaning procedures after the lab.
- Wear proper safety attire, including closed-toe shoes.
- Tie back long hair.
- Do not eat or drink anything in the lab.

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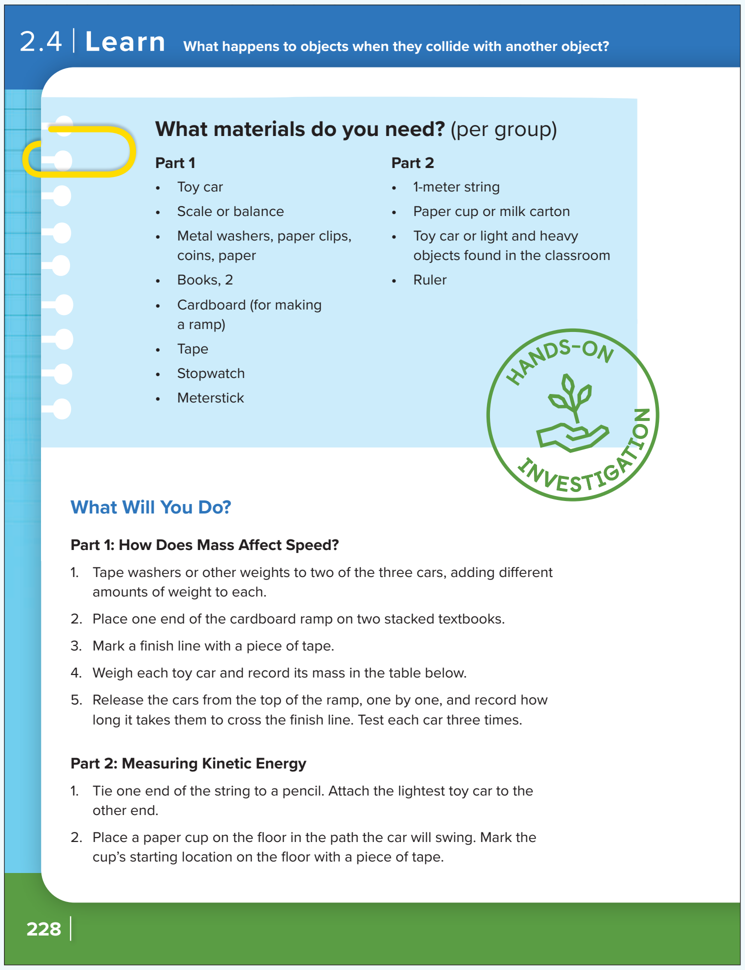

2.4 | **Learn** **What happens to objects when they collide with another object?**

What materials do you need? (per group)

Part 1

- Toy car
- Scale or balance
- Metal washers, paper clips, coins, paper
- Books, 2
- Cardboard (for making a ramp)
- Tape
- Stopwatch
- Meterstick

Part 2

- 1-meter string
- Paper cup or milk carton
- Toy car or light and heavy objects found in the classroom
- Ruler

What Will You Do?

Part 1: How Does Mass Affect Speed?

1. Tape washers or other weights to two of the three cars, adding different amounts of weight to each.
2. Place one end of the cardboard ramp on two stacked textbooks.
3. Mark a finish line with a piece of tape.
4. Weigh each toy car and record its mass in the table below.
5. Release the cars from the top of the ramp, one by one, and record how long it takes them to cross the finish line. Test each car three times.

Part 2: Measuring Kinetic Energy

1. Tie one end of the string to a pencil. Attach the lightest toy car to the other end.
2. Place a paper cup on the floor in the path the car will swing. Mark the cup's starting location on the floor with a piece of tape.

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Lesson 4, *continued*

Activity Procedure: What Will You Do?

Part 1: How Does Mass Affect Speed?

During the first investigation, students will use a procedure similar to the ones that they used in Racing Downhill and Speed and Collisions. Inform students that they will not change the angle of the incline that the toy cars move down. In this experiment, students will change the mass of the toy cars. Students may use whatever materials are available to change the mass of the cars. They may tape coins, paper clips, or other objects to the top of the car in order to change the mass. When taping, help students make sure that they do not tape over the wheels of the toy cars so that the cars may still roll down the ramp. Divide the class into the same student pairs used in the previous activities. Tell students that they may choose one angle for their incline by stacking books and that they will keep this angle for each of their tests. Remind students that one student will roll the toy car down the ramp, and the other student will measure its speed (represented by the time it takes the car to pass the finish line). Remind students that they should simply hold and release the toy car at the top of the ramp. Students should not push the cars to make them move, since they are measuring unaided speed.

Sample class plan:

1. Instruct students to place one end of the ramp on top of two stacked books, with the other end resting on the floor.
2. Allow students to choose a location for placing a piece of tape on the floor as a finish line.
3. Demonstrate for students how to measure the mass of the toy car and record that number.
4. Explain that one student will hold the stopwatch while the other places the toy car at the upper edge of the ramp.
5. The student with the toy car releases the car so that it rolls down the ramp while the student with the stopwatch measures the time it takes to pass the mark on the floor.

Lesson 4, *continued*

6. Remind students how to record the time to represent the car's speed.
7. Demonstrate for students how to add mass to the toy car by taping two coins (washers, paper clips, or something similar) to the top of the car.
8. Students repeat the experiment and record their results.

Part 2: How Does Mass Affect Kinetic Energy?

At the beginning of the second investigation, inform students that they will now be testing how an object's kinetic energy changes as its mass changes. Facilitate a class discussion on how to design a plan that tests a heavy and a light object swinging into (and knocking over) a paper cup. Students may use the toy cars from the previous investigation as well as other materials found in the classroom.

Sample class plan:

1. Show students how to tie a 1-meter piece of string with one end attached to a pencil and the other to the toy car.
2. Demonstrate how one student should stretch and hold the string horizontally so that the string stretches between the pencil and the toy car, 1 meter above the ground.
3. The second student places a paper cup on the floor, within the swinging path of the toy car, and marks the cup's starting location on the floor with a piece of tape.
4. Model how the first student should release the toy car (but hold onto the pencil) so it swings and collides into the cup. (This may take a few tries.)
5. The second student measures the distance the paper cup moved after the swinging toy car hit it.
6. As in Part 1, students tape additional materials to the toy car so that it is heavier and then tie the heavier toy car to the string.

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3. Hold the car straight out so that the cup is in the swinging path when you let go.
4. Release the car and let it collide with the cup.
5. Mark where the cup moved to with a piece of tape and measure how far this is from the starting position.
6. Repeat with heavier cars.
7. Record your results.

Data for How Mass Affects Speed

Car	Mass	Trial	Speed
1		1	
1		2	
1		3	
2		1	
2		2	
2		3	
3		1	
3		2	
3		3	

Data for Measuring Kinetic Energy

Cars (lightest to heaviest)	How many centimeters did the cup move?
1	
2	
3	

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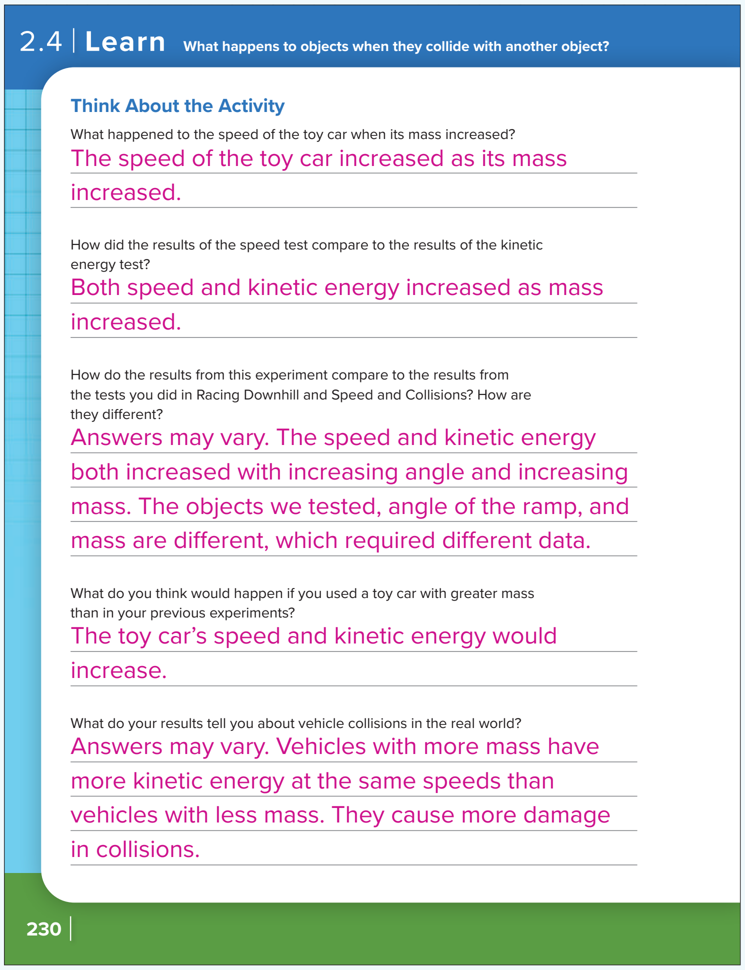

2.4 | **Learn** **What happens to objects when they collide with another object?**

Think About the Activity

What happened to the speed of the toy car when its mass increased?

The speed of the toy car increased as its mass increased.

How did the results of the speed test compare to the results of the kinetic energy test?

Both speed and kinetic energy increased as mass increased.

How do the results from this experiment compare to the results from the tests you did in Racing Downhill and Speed and Collisions? How are they different?

Answers may vary. The speed and kinetic energy both increased with increasing angle and increasing mass. The objects we tested, angle of the ramp, and mass are different, which required different data.

What do you think would happen if you used a toy car with greater mass than in your previous experiments?

The toy car's speed and kinetic energy would increase.

What do your results tell you about vehicle collisions in the real world?

Answers may vary. Vehicles with more mass have more kinetic energy at the same speeds than vehicles with less mass. They cause more damage in collisions.

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Lesson 4, *continued*

7. Students repeat the experiment with the heavier toy car tied to the string.
8. Remind students to record their results.

Analysis and Conclusions: Think About the Activity

ASK

- *What happened to the speed of the toy car when its mass increased?*
  When the mass increased, the speed increased.
- *How did the results of the speed test compare to the results of the kinetic energy test?*
  Both speed and kinetic energy increased as mass increased.
- *How do the results from this experiment compare to the results from the tests you did in Racing Downhill and Speed and Collisions? How are they different?*
  Answers may vary. The speed and kinetic energy both increased with increasing angle and increasing mass. The variables, angle, and mass are different, which required different data.

Teacher Reflection

- Can my students identify the strengths and weaknesses of design ideas?
- What data did my students struggle with during the Hands-On Investigation?
- What examples of extension activities could I include the next time I teach this lesson?

Lesson 5

Does Energy Disappear in a Collision?

Activity 9
Analyze Like a Scientist

20 min

Energy Conversions during a Collision

Purpose

Students have built conceptual and experiential understanding of how mass and speed affect a collision. This activity deepens student understanding of energy in a collision by exploring a concrete demonstration of energy conversion.

Instructional Focus

In this activity, students identify the transfer of energy in a Newton's cradle by reading a scientific text, watching a video, and discussing with peers.

Strategy

Video resources are designed to help students meet instructional goals. If your students cannot access the videos, text has been provided to support learning.

Show students the video of Newton's cradle. If you have a Newton's cradle, display how it works.

ASK Does the cradle keep working forever? If not, why?
Student answers will vary. Students may reference friction as one of the reasons the cradle will eventually stop.

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Does Energy Disappear in a Collision?

Activity 9
Analyze Like a Scientist

Quick Code: egs4155

Energy Conversions during a Collision

You already know that when two objects collide there is a transfer of energy. When you play a game with marbles, kinetic energy is transferred from your arm to the marble. Then, there is a transfer of energy from your marble to the ones you hit to knock out of the triangle. Click! That sound you hear when the marbles collide is energy, too. Where did this sound energy come from? **Read** the text about Newton's cradle. As you read, **highlight** all the forms of energy to which kinetic energy is transformed. **Watch** the video for a demonstration.

Energy Conversions during a Collision

From what you have observed, you know that when objects collide, energy changes and transfers take place. The amount of energy depends on the kinetic energy of the objects and the direction in which they are traveling. Their kinetic energy is determined by both their speed and their mass. What happens to all this kinetic energy when objects collide?

Video

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Photo Credit: Pixabay

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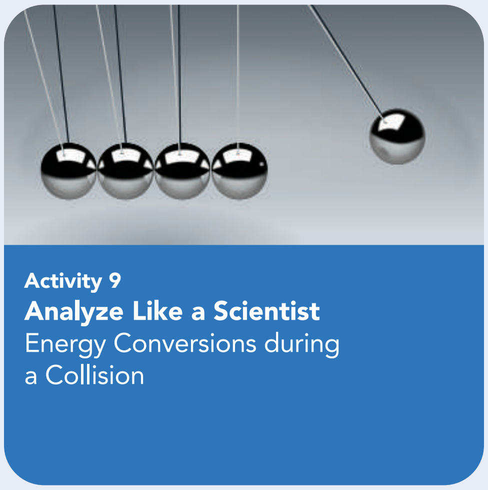

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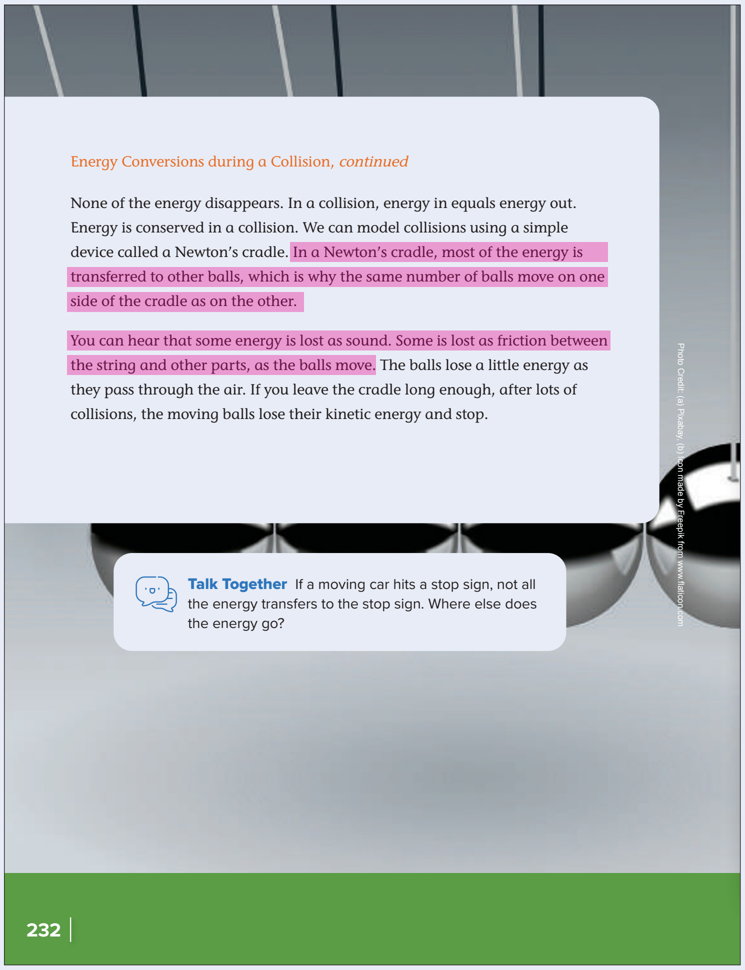

Energy Conversions during a Collision, *continued*

None of the energy disappears. In a collision, energy in equals energy out. Energy is conserved in a collision. We can model collisions using a simple device called a Newton's cradle. In a Newton's cradle, most of the energy is transferred to other balls, which is why the same number of balls move on one side of the cradle as on the other.

You can hear that some energy is lost as sound. Some is lost as friction between the string and other parts, as the balls move. The balls lose a little energy as they pass through the air. If you leave the cradle long enough, after lots of collisions, the moving balls lose their kinetic energy and stop.

Talk Together If a moving car hits a stop sign, not all the energy transfers to the stop sign. Where else does the energy go?

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Lesson 5, *continued*

Provide students with time to read the text that describes the conversion of energy during a collision. Ask students to highlight all the types of energy to which kinetic energy is transferred when the balls strike one another. Once students have finished reading, facilitate a discussion about the prompt in the Talk Together box.

Revisit students' answer to the question, Does the cradle keep working forever?

ASK *Now that you have learned more, would you change your answer? How so?*

MISCONCEPTION

Energy transfer is a messy process. If a car collides with a stop sign, the kinetic energy is transferred from the car to the stop sign. What happens to the sign does not account for all of the car's energy though. Some of the kinetic energy becomes sound energy or heat energy. Students at this level do not need to understand how to make calculations associated with how much energy converts to which other types of energy. They should, however, understand that multiple energy conversions can result from a collision.

Lesson 5, *continued*

Scientific Explanation

Activity 10
Record Evidence Like a Scientist

25 min

Collision

Purpose

Students return to the questions posed at the beginning of the concept and reconsider what they know now. The process of writing a scientific explanation using evidence to support a claim is a key step in students constructing scientific knowledge that they can then use and apply.

Instructional Focus

In this activity, students construct a scientific explanation about the Investigative Phenomenon Collision and the Can You Explain? question.

Life Skills **Creativity**

Strategy

Display the Investigative Phenomenon of Collision and the Can You Explain? question. Ask students to discuss and share with the class or a partner their explanation for the Investigative Phenomenon Collision.

After allowing students to discuss,

ASK *How can this explanation help you answer the Can You Explain? question?*

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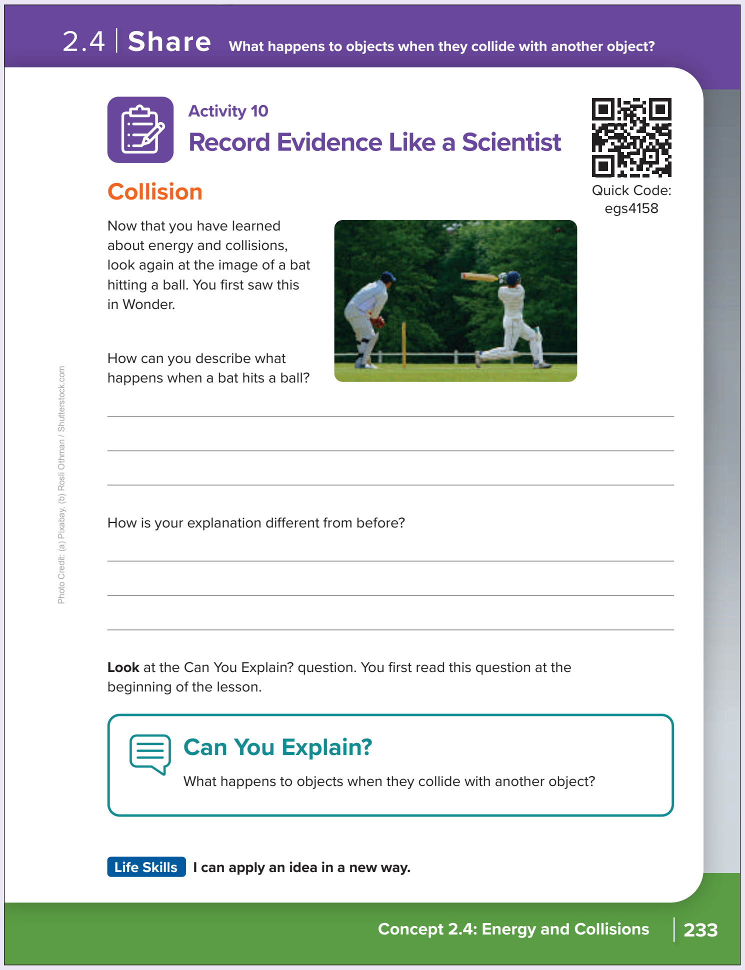

2.4 | **Share** What happens to objects when they collide with another object?

Activity 10
Record Evidence Like a Scientist

Quick Code: egs4158

Collision

Now that you have learned about energy and collisions, look again at the image of a bat hitting a ball. You first saw this in Wonder.

How can you describe what happens when a bat hits a ball?

How is your explanation different from before?

Look at the Can You Explain? question. You first read this question at the beginning of the lesson.

Can You Explain?
What happens to objects when they collide with another object?

Life Skills I can apply an idea in a new way.

Photo Credit: (a) Pixabay, (b) Rosli Othman / Shutterstock.com

Concept 2.4: Energy and Collisions | 233

Photo Credit: Rosli Othman / Shutterstock.com

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Activity 10
Record Evidence Like a Scientist
Collision

Quick Code:
egst4158

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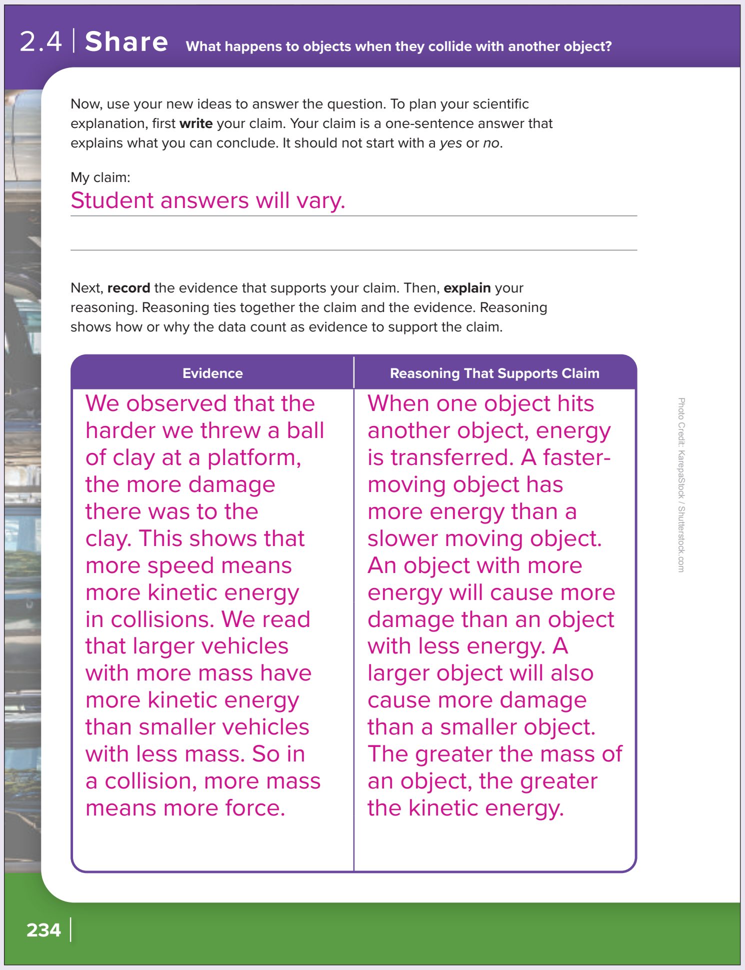

2.4 | **Share** What happens to objects when they collide with another object?

Now, use your new ideas to answer the question. To plan your scientific explanation, first **write** your claim. Your claim is a one-sentence answer that explains what you can conclude. It should not start with a *yes* or *no*.

My claim:
Student answers will vary.

Next, **record** the evidence that supports your claim. Then, **explain** your reasoning. Reasoning ties together the claim and the evidence. Reasoning shows how or why the data count as evidence to support the claim.

Evidence	Reasoning That Supports Claim
We observed that the harder we threw a ball of clay at a platform, the more damage there was to the clay. This shows that more speed means more kinetic energy in collisions. We read that larger vehicles with more mass have more kinetic energy than smaller vehicles with less mass. So in a collision, more mass means more force.	When one object hits another object, energy is transferred. A faster-moving object has more energy than a slower moving object. An object with more energy will cause more damage than an object with less energy. A larger object will also cause more damage than a smaller object. The greater the mass of an object, the greater the kinetic energy.

Photo Credit: KampaStock / Shutterstock.com

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Lesson 5, *continued*

As students would have already reviewed sample scientific explanations in earlier units, they should be familiar with the claim, reasoning, and evidence framework. You may want to review the following:

A **claim** is a one-sentence answer to the question you investigated. It answers, what can you conclude? It should not start with *yes* or *no*.

Evidence must be:

- Sufficient—Use enough evidence to support the claim.
- Appropriate—Use data that support your claim. Leave out information that doesn't support the claim.

Reasoning ties together the claim and the evidence, and:

- Shows how or why the data count as evidence to support the claim.
- Provides the justification for why this evidence is important to this claim.
- Includes one or more scientific principles that are important to the claim and evidence.

Can You Explain?

What happens to objects when they collide with another object?

After providing scaffolding to the students, for those students able to do so, allow them to construct a full scientific explanation. They can write, draw, or orally describe their claim, evidence, and reasoning.

Lesson 5, *continued*

Sample student response:
The amount of energy a moving object has depends on its mass and its speed. A heavy moving object possesses more energy than a lighter moving object traveling at the same speed. An object that moves fast has more energy than an object of the same mass that is moving slowly. Therefore, a car of the same mass will do more damage to a wall if it is moving faster. When objects collide, energy is transferred. Sometimes that energy is transferred into kinetic energy, heat, and sound. In the reading and video, we learned that energy in a Newton's cradle is transferred into sound and friction as the balls move. The moving balls eventually lose all their kinetic energy and stop.

Differentiation

APPROACHING LEARNERS

For glossary terms such as *speed* and *mass*, have students draw representations or write a description to help them visualize the concepts.

Have students demonstrate concepts by acting them out. For example, students could act out pushing a chair as an example of force.

Teacher Reflection

- How have my students' construction of scientific explanations improved from earlier in the course?
- How did I provide scaffolding for students to construct their scientific explanations? Do I need to scaffold more or less for their next scientific explanation?
- How do I know my students are ready to apply the core content knowledge to another context?

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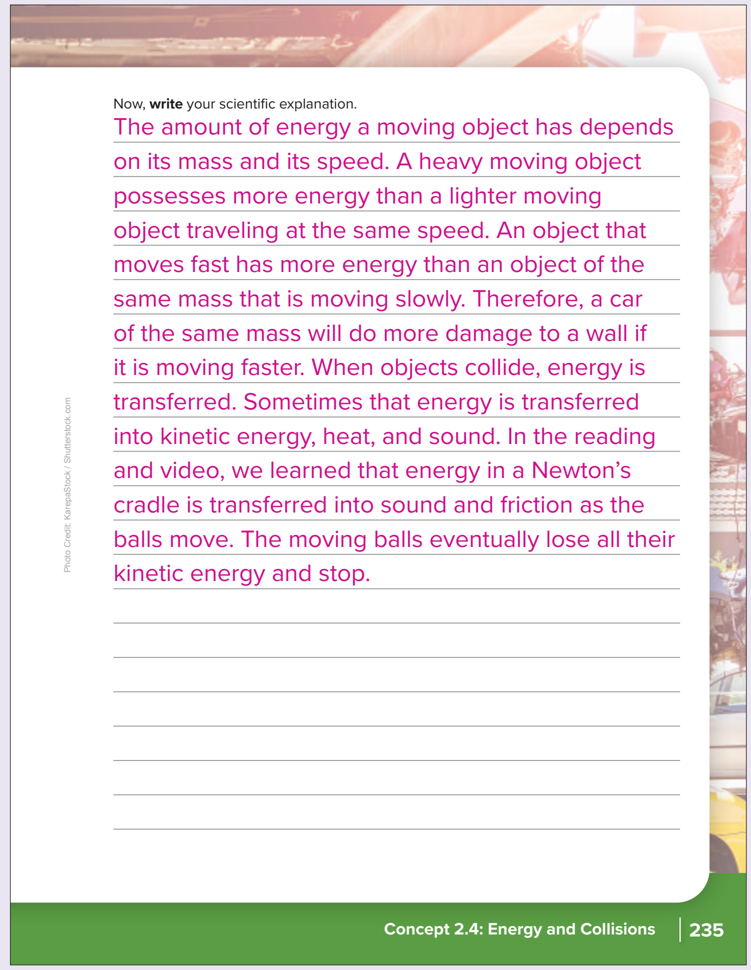

Now, **write** your scientific explanation.

The amount of energy a moving object has depends on its mass and its speed. A heavy moving object possesses more energy than a lighter moving object traveling at the same speed. An object that moves fast has more energy than an object of the same mass that is moving slowly. Therefore, a car of the same mass will do more damage to a wall if it is moving faster. When objects collide, energy is transferred. Sometimes that energy is transferred into kinetic energy, heat, and sound. In the reading and video, we learned that energy in a Newton's cradle is transferred into sound and friction as the balls move. The moving balls eventually lose all their kinetic energy and stop.

Concept 2.4: Energy and Collisions | 235

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STEM in Action

Quick Code: egs4159

Activity 11

Analyze Like a Scientist

Crash Investigator

Do you like to solve puzzles? Are you good at looking for important details? If so, then you may be interested in a career as a crash investigator. **Read** the text. As you read, **highlight** the different measurements that a crash investigator needs to take.

Crash Investigator

Crash investigators see a car crash as a puzzle. To solve the puzzle, they use scientific laws of motion. Scientists use evidence to explain that an object in motion continues in motion until something stops it.

Car Crash

Photo Credit: Pixabay

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Photo Credit: Pixabay

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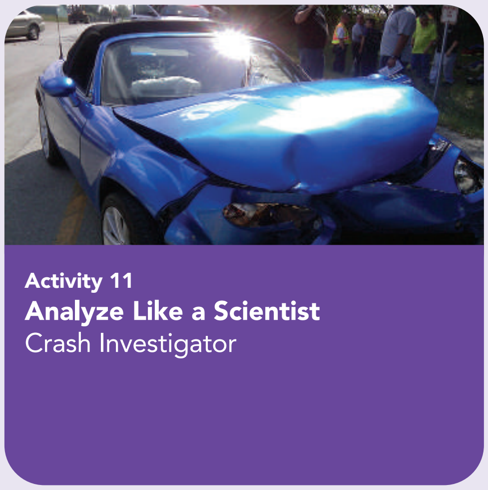

Quick Code:
egst4159

Lesson 6

STEM in Action

Activity 11

Analyze Like a Scientist

20 min

Crash Investigator

Purpose

Students explore the real-world career of a crash investigator who analyzes the relationship between speed and protecting passengers in a vehicle in order to develop their own ideas for the Unit Project.

Instructional Focus

In this activity, students simulate crash investigators' work by analyzing images of different car crash scenarios.

Strategy

Instruct students to read the text on crash investigations. Instruct students to highlight in the text the different measurements that a crash investigator needs to take to solve the case.

ASK *Take a look at the photo Car Crash. What can you assume about the object that hit the car? Why do you think that?*

Lesson 6, *continued*

ENTREPRENEURSHIP

Entrepreneurs often look for opportunities in new situations. Car crash investigators use this skill when trying to determine the cause of a crash. Entrepreneurs look for ways to be creative when solving problems. As students read the passage, prompt them to consider ways that a car crash investigator has to use creativity and other entrepreneurship skills.

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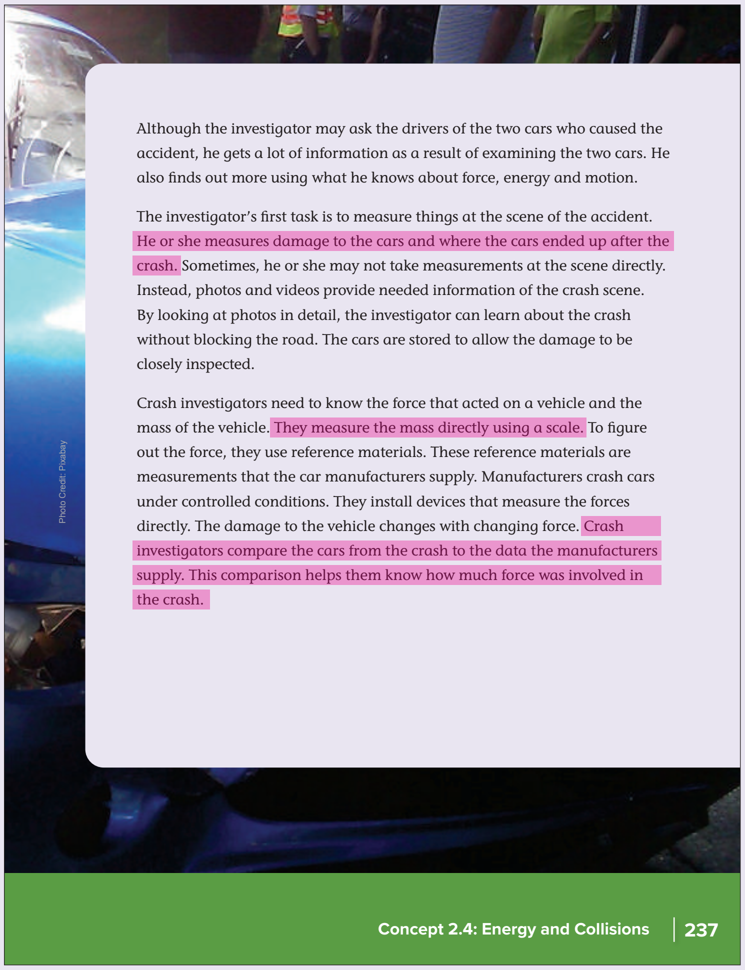

Although the investigator may ask the drivers of the two cars who caused the accident, he gets a lot of information as a result of examining the two cars. He also finds out more using what he knows about force, energy and motion.

The investigator's first task is to measure things at the scene of the accident. He or she measures damage to the cars and where the cars ended up after the crash. Sometimes, he or she may not take measurements at the scene directly. Instead, photos and videos provide needed information of the crash scene. By looking at photos in detail, the investigator can learn about the crash without blocking the road. The cars are stored to allow the damage to be closely inspected.

Crash investigators need to know the force that acted on a vehicle and the mass of the vehicle. They measure the mass directly using a scale. To figure out the force, they use reference materials. These reference materials are measurements that the car manufacturers supply. Manufacturers crash cars under controlled conditions. They install devices that measure the forces directly. The damage to the vehicle changes with changing force. Crash investigators compare the cars from the crash to the data the manufacturers supply. This comparison helps them know how much force was involved in the crash.

Photo Credit: Pixabay

Concept 2.4: Energy and Collisions | 237

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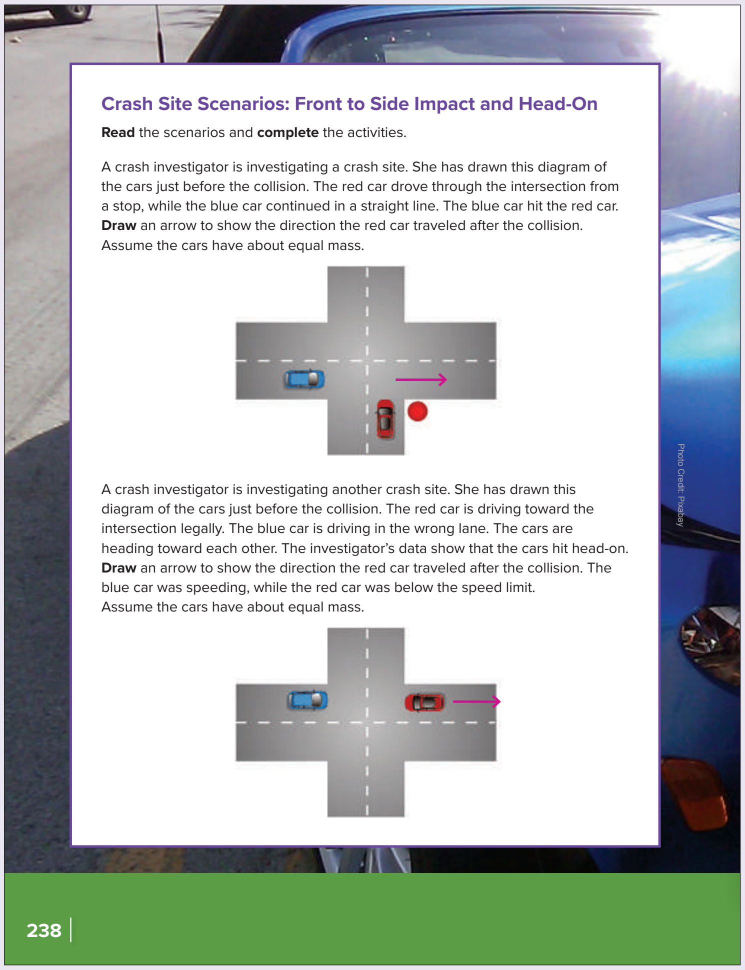

Crash Site Scenarios: Front to Side Impact and Head-On

Read the scenarios and **complete** the activities.

A crash investigator is investigating a crash site. She has drawn this diagram of the cars just before the collision. The red car drove through the intersection from a stop, while the blue car continued in a straight line. The blue car hit the red car. **Draw** an arrow to show the direction the red car traveled after the collision. Assume the cars have about equal mass.

A crash investigator is investigating another crash site. She has drawn this diagram of the cars just before the collision. The red car is driving toward the intersection legally. The blue car is driving in the wrong lane. The cars are heading toward each other. The investigator's data show that the cars hit head-on. **Draw** an arrow to show the direction the red car traveled after the collision. The blue car was speeding, while the red car was below the speed limit. Assume the cars have about equal mass.

Photo Credit: Pixabay

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Lesson 6, *continued*

Crash Site Scenarios: Front to Side Impact and Head-On

This portion of the activity shows two different crash site scenarios. Students should use their knowledge of energy and collisions to complete the activities. The work can be completed in small groups.

Lesson 6, *continued*

Review and Assess

Activity 12
Evaluate Like a Scientist

25 min

Review: Energy and Collisions

Purpose

The final activity of the concept asks students to review and explain the main ideas of energy and collisions. This activity allows students to reflect on what they understand about collisions and how to relate to the overall Unit Project, focusing on vehicle safety.

Instructional Focus

In this activity, students will summarize their learning and apply it to the big ideas of the unit.

Strategy

Now that students have achieved this concept's objectives, direct them to review the key ideas. Then ask students to discuss the topic in the Talk Together box to help them prepare for the Unit Project.

Teacher Reflection

- How many of my students met the objectives for this concept?
- For students who did not meet the objectives, what are my next steps?

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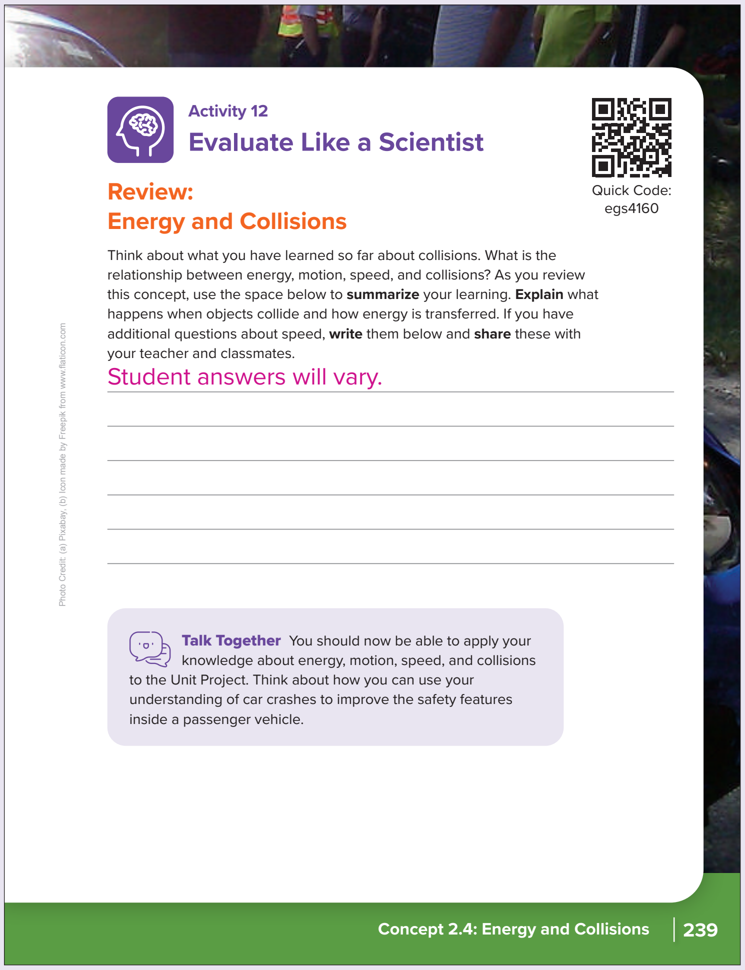

Activity 12

Evaluate Like a Scientist

Quick Code: egs4160

Review: Energy and Collisions

Think about what you have learned so far about collisions. What is the relationship between energy, motion, speed, and collisions? As you review this concept, use the space below to **summarize** your learning. **Explain** what happens when objects collide and how energy is transferred. If you have additional questions about speed, **write** them below and **share** these with your teacher and classmates.

Student answers will vary.

Talk Together You should now be able to apply your knowledge about energy, motion, speed, and collisions to the Unit Project. Think about how you can use your understanding of car crashes to improve the safety features inside a passenger vehicle.

Photo Credit: (a) Pixabay, (b) Icon made by Freepik from www.flaticon.com

Concept 2.4: Energy and Collisions | 239

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Activity 12
Evaluate Like a Scientist
Review: Energy and Collisions

Quick Code: egst4160

Unit Project

Solve Problems Like a Scientist

80 min

Vehicle Safety

Instructional Focus

The Unit Project allows students to return to the anchor phenomenon for the unit, the Science of Car Crashes, and apply the unit learning standards to solve or research a problem.

Students research safety features of vehicles and use their research to design, test, and refine a device that transfers the energy of impact into a mechanism that will protect passengers from injury during a collision. Students must identify the types of crashes the new safety features protect against, the forces involved in these crashes, and the specific ways in which the safety features counteract these forces.

Life Skills **Problem-Solving**

Strategy

Use the video *What Is an Airbag?* if available, and the provided text from the Unit Project Preview, along with ideas from the final concept that outlined how train airbags are used as protective devices. Encourage students to discuss, brainstorm, and list a wide variety of devices and technologies in vehicles that provide protection. You may want students to complete the project individually or in pairs. Remind students to cite their research sources in their presentations or reports.

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Unit Project

Solve Problems Like a Scientist

Quick Code: egs4162

Unit Project: Vehicle Safety

Car makers design vehicles for safety. But how do they know what happens to cars during different types of crashes? Is it possible to design cars that are safe in all types of crashes?

Car Crash

Photo Credit: (a) Volodymyr Baleha / Shutterstock.com, (b) Thanin Sinlapachai / Shutterstock.com

Life Skills I can use information to solve a problem.

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Quick Code: egst4162

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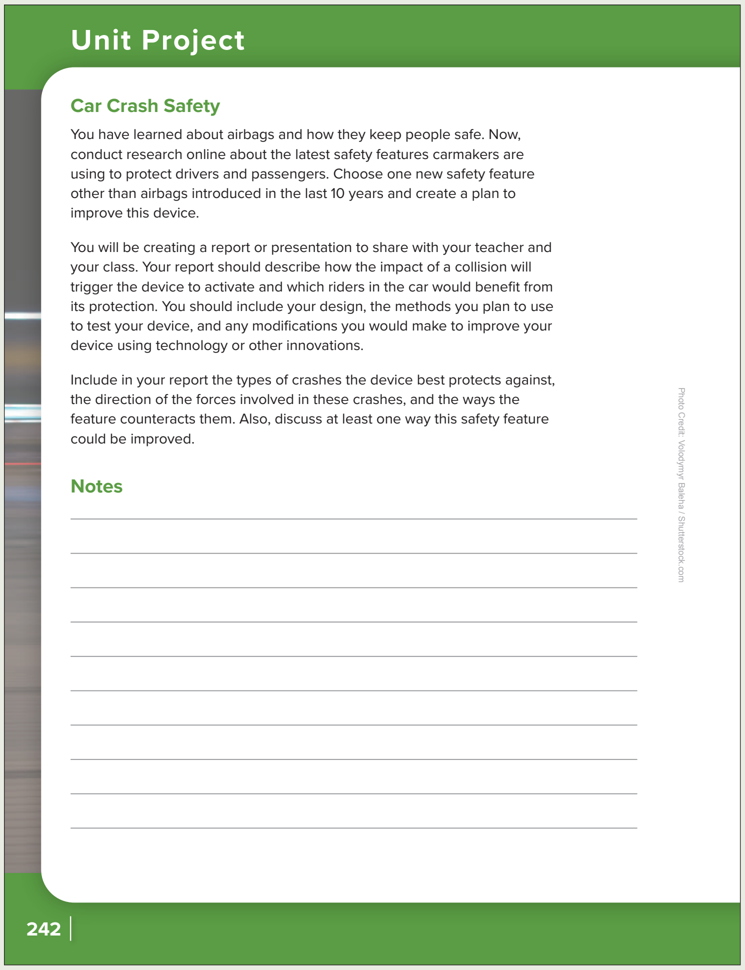

Unit Project

Car Crash Safety

You have learned about airbags and how they keep people safe. Now, conduct research online about the latest safety features carmakers are using to protect drivers and passengers. Choose one new safety feature other than airbags introduced in the last 10 years and create a plan to improve this device.

You will be creating a report or presentation to share with your teacher and your class. Your report should describe how the impact of a collision will trigger the device to activate and which riders in the car would benefit from its protection. You should include your design, the methods you plan to use to test your device, and any modifications you would make to improve your device using technology or other innovations.

Include in your report the types of crashes the device best protects against, the direction of the forces involved in these crashes, and the ways the feature counteracts them. Also, discuss at least one way this safety feature could be improved.

Notes

Unit Project, *continued*

ASK

- *What types of crashes will your device protect against?*
  Answers will vary. Students should identify a general range of speed that the vehicles can be travelling for the device to remain effective (neighborhood speed, highway speed, etc.), the direction of travel that the two cars could be moving in when the impact occurs, as well as which travelers (driver, front-seat passenger, back-seat passengers, etc.) would benefit from protection.
- *What forces are involved in these types of crashes?*
  Answers will vary. Students should connect crashes to kinetic and potential energy.
- *What ways will your new safety feature counteract these forces?*
  Answers will vary. Students should be able to describe how the device that they have chosen will absorb the transfer of energy that occurs during a collision, sparing the passengers in the car from the injury that occurs when energy is transferred to the human body during an impact.

Primary 4 Resources

- Concept Assessments
- Graphic Organizers
- Safety in the Science Classroom
- Glossary
- Index

Concept Assessment
Unit 1, Concept 1: Adaptation and Survival

Name ______________________ **Date** ______________

Instructions
Please answer each question carefully.

1. What is adaptation?

- **A.** It is a process by which organisms create offspring.
- **B.** It is a characteristic that has changed over time to help living things survive and reproduce.
- **C.** It is a form of pollination used by conifers.
- **D.** It is a form of excretion that organisms with a digestive system use to get rid of waste.

2. Imagine taking some fish from coastal waters and transferring them into a deep, dark, sea cave. Which characteristics would the new fish be missing that other animals, already living in the deep sea environment, might exhibit as adaptations?

Circle all the characteristics that apply.

Brilliant colors	Big fins	Colorless skin	More efficient gills
Good eyesight	Great hunting abilities	Poor eyesight	Thick scales

3. Which would die if it did not have the right adaptations for survival in its environment?

- **A.** a rock
- **B.** a car
- **C.** an apple tree
- **D.** a glass

Concept Assessment
Unit 1, Concept 1: Adaptation and Survival

Name ______________________________ **Date** ____________________

4. What happens to organisms that do not have the right adaptations for the conditions of their environment?

A. The population increases.

B. The organisms die off.

C. The population stays the same.

D. The biodiversity of the ecosystem increases.

5. How do adaptations affect the survival rate of a species?

A. Adaptations decrease the survival rate of a species.

B. Adaptations increase the survival rate of a species.

C. Adaptations change all of the organism's structures.

D. Adaptations change all of the organism's learned behaviors.

6. The growth of a plant is influenced by its adaptations to the weather conditions. A student observes that a desert plant fails to grow in humus-rich well-watered soil. The most likely reason for this is that ______.

A. humus prevents plant growth

B. a desert plant survives in less water

C. water easily drains out in a humus soil

D. a desert plant needs more nutrients in the soil for growth

7. Antelope that live in wide, open plains must adapt by using

A. thick fur which helps to keep them warm in winter.

B. long legs which help them run fast.

C. bright colors to help them attract a mate.

D. their hard outer shell to protect them.

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________________ **Date** ____________________

Instructions
Please answer each question carefully.

1. Read the following scenario. In which part of the event is your nervous system receiving a message?

- **A.** You touch your finger to a cactus thorn.
- **B.** You pull your hand away.
- **C.** You yell "Ouch!"
- **D.** Your finger begins to bleed.

2. What are the two organs that make up the central nervous system?

- **A.** the brain's cerebellum and the spine
- **B.** the sympathetic and parasympathetic nervous system
- **C.** the sensory and motor system
- **D.** the spinal cord and the brain

3. Azza suddenly woke up and smelled something burning. She crept down the stairs to see what was happening. She found her parents reading and sitting by the fire place, which was burning wood. Why did Azza wake up?

- **A.** The smell of the fire sent a signal through her blood cells to her brain and she woke up.
- **B.** The smell of the fire sent a signal through her nerves to her brain and she woke up.
- **C.** Azza's nose was stuffy from a cold and she could not sleep.
- **D.** Azza was too cold upstairs to sleep.

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

4. Eyes squint instinctively to avoid light when bright light falls on them suddenly. Which two systems are involved in this process?

A. nervous and muscular

B. nervous and respiratory

C. circulatory and muscular

D. circulatory and respiratory

5. On a hot summer day, Malek left the pool and began to climb a ladder to his tree house. He hurt his toe by bumping it on the ladder as he climbed into the tree house. How did Malek know that he had hurt his toe?

A. The nerves in his hurt toe sent a signal through his body to his brain.

B. The blood cells in his toe sent a signal through his body to his brain.

C. Malek's toes became very cold and numb.

D. Malek's toe became smaller than before he had bumped it on the ladder.

6. Rami stopped suddenly on his bike because he heard a car speed by him. Which system received the external signal of hearing that enabled Rami to respond by stopping his bike?

A. circulatory system

B. excretory system

C. muscular system

D. nervous system

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

7. How is your nervous system like a pizza delivery restaurant?

- **A.** It needs fuel to run efficiently.
- **B.** Orders are sent out based upon the different messages that come in.
- **C.** It can take a long time for messages to be delivered and sent out.
- **D.** Not everyone sends his or her orders to the same location.

8. Match each sensory organ by drawing a line to the type of information that the organ's receptors collect.

Sensory Organ	**Sensory Information**
A. Hand	**1.** light coming through an open window
B. Eyes	**2.** a skunk's foul scent
C. Tongue	**3.** heat from a hot stove
D. Ears	**4.** the bitter taste of a lemon
E. Nose	**5.** a loud noise blasting from car speakers

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

9. Indicate if the following statements about the nervous system are true or false by placing a **T** (true) or **F** (false) in the column to the left.

_______ Nerves are constantly receiving information from the senses and sending them to the brain, even while a person is sleeping.

_______ When a person steps on a sharp rock with their bare foot, their brain is the last organ to react to the information.

_______ Each sense organ in the nervous system works on its own, independently from the brain, when the brain is busy doing other jobs for the body.

_______ If someone were to burn their hand, the brain can store that memory so that it can tell them to move his or her hand the next time a hot surface is nearby.

10. Students in a classroom hear a tornado siren go off. Which of the following could be ways in which they respond? Read the selections and place a check (✓) next to the correct responses.

_______ The ears sense a loud sound causing the brain to send a message for their hands to cover the ears.

_______ Their noses sense something that smells bad causing the brain to send a message to students' hands to pinch their noses shut.

_______ The siren sends a message to the students' brains that causes them to remember a scary tornado event last year. It also signals their brain to send a message for the students to yell in alarm.

_______ The ears pick up noise and the brain tells the legs to jump out of the seat.

_______ Students sense sound with their ears and the brain sends a message to the hands to rub their elbows in pain.

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________________ **Date** ____________________

11. Place the sentences in order of how the information is processed by the brain. Use **1** for the statement that happens first and **4** for the statement which happens last.

_______ Nerves in the body connect the sense organs to the brain.

_______ Information from the environment is received by a sense organ.

_______ The brain determines what to do with the information.

_______ The signals travel as electrical pulses from the organ to the nerves in the brain.

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ______________________ **Date** ______________

Instructions
Please answer each question carefully.

1. Which of the following is a source of light?

- **A.** the moon
- **B.** our eyes
- **C.** fire
- **D.** a mirror

2. What property of light helps you see yourself in a mirror?

- **A.** refraction
- **B.** reflection
- **C.** absorption
- **D.** relativity

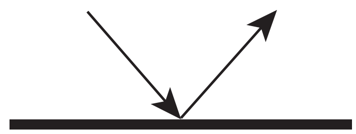
3. Which statement best explains why you can see yourself when you look at a mirror?

- **A.** Light is refracted as it passes through the mirror.
- **B.** Light is reflected, bouncing off the mirror.
- **C.** Light is refracted, bouncing off the mirror.
- **D.** Light is reflected as it passes through the mirror.

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ______________________________ **Date** ____________________

4. The arrows in each answer choice represent light rays. Which drawing shows how light is reflected by a mirror?

A.


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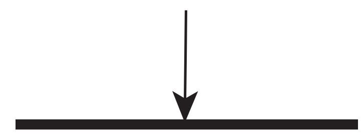

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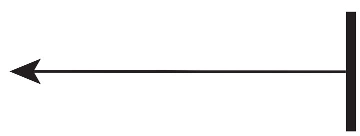
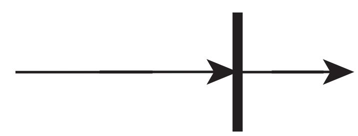


D.


5. What type of surface scatters light unevenly?

A. shiny
B. rough
C. smooth
D. transparent

6. What word is used to describe light as it strikes a smooth, shiny surface and bounces off?

A. shadow
B. energy
C. reflection
D. wave length

7. What happens to light when it hits a rough surface?

A. scattering
B. reflection
C. absorption
D. refraction

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ______________________ **Date** ______________

8. Salma visited a lake surrounded by mountains. She observed the image of the mountains on the surface of the lake's water.

Photo Credit: Js.One / Shutterstock.com

Salma built a diorama to model what she saw. She used a postcard of a mountain scene to represent the mountains and a small mirror to represent the lake. Which is the best explanation of why her model represents what she saw?

- **A.** The mirror refracts light onto the image of the mountain on the postcard
- **B.** The mirror reflects light onto the image of the mountain on the postcard.
- **C.** The image of the mountain on the postcard is refracted by the mirror.
- **D.** The image of the mountain on the postcard is reflected by the mirror.

9. Which set of objects below would all reflect light well?

- **A.** aluminum foil, brick wall, mirror
- **B.** metal spoon, tree trunk, aluminum foil
- **C.** mirror, metal spoon, brick wall
- **D.** metal spoon, mirror, aluminum foil

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________ **Date** ______________

Instructions

Please answer each question carefully.

1. Imagine you are riding in a car down the highway. Read the selections and place a check (✓) next to the objects that you can look at to let you know the car is in motion.

   ________ The soccer ball sitting in the seat next to you.

   ________ The sign of the highway telling you the speed limit.

   ________ The can of soda in the cup holder.

   ________ The light pole you see out the window.

   ________ The parked car that you pass on the road.

2. Read the selections and place a check (✓) next to the two sentences that describe the exertion of force on a wheelbarrow.

   ________ Ziad is going to use a wheelbarrow to haul rocks from one area to another.

   ________ The wheelbarrow is sitting at one end of the path.

   ________ Ziad loads rocks from a pile nearby into the wheelbarrow.

   ________ Once the wheelbarrow is full of rocks, they are ready to be moved to the opposite end of the path.

   ________ Ziad lifts the wheelbarrow's handles and pushes it along the path.

   ________ After arriving at the destination, he prepares to dump the rocks.

   ________ He pushes the handles of the wheelbarrow upward so that the rocks fall out of the front.

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________________ **Date** ____________________

3. The class is playing tug of war in the courtyard. There are 10 students on either side of the rope. What would explain that no one has moved?

A. One team has more force than the other.

B. One team has half the force of the other.

C. The teams have equal and opposite forces.

D. The teams have unequal and opposite forces.

4. Review each statement below and decide if it describes a change in position, a change in both position and direction, or neither. Write the appropriate abbreviation in the column to the left of each statement.

P = change in position

PD = change in position and direction

N = neither

________ A soccer ball is kicked.

________ A glass sits on a table.

________ A rocket is shot up into the air then falls to the ground.

________ A moving train turns north.

________ A bus travels 50 kilometers in a straight line.

________ A sailboat moving forward is pushed left by a gust of wind.

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________________ **Date** ____________________

5. Review each statement below and decide if the motion of the objects below will be stopped by either the force of friction or by a collision with another object. Write the appropriate abbreviation in the column to the left of each statement.

F = Force of Friction

C = Collision

________ A soccer ball rolls across a field.

________ A car rolls into a wall.

________ A pitcher throws a baseball to the catcher.

________ A rugby player is tackled during a game.

________ A girl on a swing eventually stops swinging.

6. Which of the following indicates motion?

A. bicycle

B. sunlight

C. running water

D. guitar string

7. Circle the two sentences about force that are true.

A force always causes movement.	Two forces can be unbalanced.
A force is a push or a pull.	Forces are only created by people.
Two forces must be equal.	A force always leads to work.

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________________ **Date** ____________________

8. A toy car is sitting still in the driveway. Nawal kicks the car and it spins moving sideways. The car is considered in motion because ______.

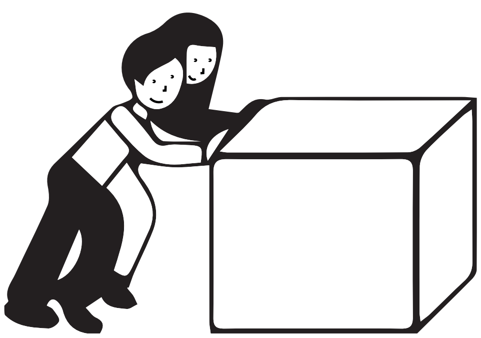
A. the car was kicked

B. the car did a wheelie

C. the car has four wheels

D. the position of the car changed

9. Fatma is pushing a big box. Ezz comes to help her.



How does this change the force and motion of the box?

A. It does not change the force or the motion.

B. It increases the force and decreases the motion.

C. It increases the force and increases the motion.

D. It decreases the force and increases the motion.

10. Heba notices that the position of her golf ball on the green has changed in comparison to the flagpole in the hole. This change is a result of ______.

A. motion of the flagpole

B. motion of the ball

C. speed of the ball

D. speed of the flagpole

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________________ **Date** ______________

Instructions
Please answer each question carefully.

1. When gasoline is burned, stored chemical energy is released in the form of ______ and light.

- **A.** fumes
- **B.** carbon dioxide
- **C.** sparks
- **D.** heat

2. You toss a ball into the air. The ball falls and then bounces back into the air. What happens to its energy?

- **A.** All of the energy remains unchanged.
- **B.** More energy is created as the ball bounces.
- **C.** Some energy is destroyed as the ball bounces.
- **D.** Some energy changes to other forms of energy.

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________________ **Date** ______________

3. There are lots of ways one form of energy can be transformed into another form.

Draw a line to match the action with the correct energy transformation. *Each action will match an energy transformation. Not all of the energy transformations will have a match to an action.*

Action	Energy Transformation
A. Dalia lifts a bowling ball to the top of a slide.	**1.** motion → sound
B. The ball begins to roll down the slide.	**2.** chemical → electrical
C. The rolling ball makes a lot of noise on the metal slide.	**3.** gravitational potential → motion
D. The ball strikes the head of a nail which gets pounded into a piece of wood, heating the nail and wood a little.	**4.** motion → gravitational potential
	5. motion → thermal
	6. motion → light

4. When you clap your hands, what happens to the energy of motion in your hands?

- **A.** It becomes sound energy and heat energy.
- **B.** It becomes potential energy and solar energy.
- **C.** Some is lost, and some becomes sound energy.
- **D.** Some is lost, and some becomes chemical energy.

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________________ **Date** ______________

5. Which ball has kinetic energy but not potential energy?

A. a ball rolling down a ramp

B. a ball sitting on a high shelf

C. a ball bouncing up and down

D. a ball rolling on a flat sidewalk

6. Which type of energy change occurs when a person rides a bike?

A. heat energy changes to potential energy

B. chemical energy changes to kinetic energy

C. solar energy changes to chemical energy

D. kinetic energy changes to nuclear energy

7. Which of the following can store energy?

A. battery

B. wire

C. plastic

D. rubber

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________________________ **Date** ____________________

8. Examples of how we use energy are listed below. Write the form of energy used in the column on the left.

Chemical	Motion	Light
Sound	Electricity	

____________________ You hear a dog barking at a cat.

____________________ Your cell phone uses a battery.

____________________ A girl roller skates on the sidewalk.

____________________ Your body uses glucose for energy.

____________________ You see lights coming towards you.

____________________ Gasoline explodes inside a bus engine.

____________________ You use a flashlight on a camping trip.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________________ **Date** ____________________

Instructions
Please answer each question carefully.

1. Read each situation below and decide if the speed of the object will increase or decrease, based on the force that is applied to it. Write INCREASE or DECREASE in the column on the left.

__________________ A sailboat gets pushed from behind by a gust of wind.

__________________ A ball rolls into a wall.

__________________ A soccer ball is kicked.

__________________ A man pulls on the leash of a dog, as the dog tries to run away.

__________________ A pitcher throws a baseball.

2. Read the statements below to determine the ones that give enough information to calculate the speed of the object. Place a check (✓) next to the statements apply.

______ A boy ran 4 kilometers on a cold and windy morning.

______ A car was able to travel 200 kilometers in 4 hours.

______ A plane was in the air for 6 hours and went higher than 8,000 meters.

______ A horse ran around the 2-kilometer racetrack in 2 minutes.

______ A boat traveled 4 kilometers across the lake when the temperature was 13°C.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ **Date** ______________

3. How is speed measured?

- **A.** distance traveled per unit of time
- **B.** time per unit of distance traveled
- **C.** mass per unit of distance traveled
- **D.** volume per unit of mass

4. Which formula can be used to calculate speed?

- **A.** distance/time
- **B.** time/distance
- **C.** mass/time
- **D.** time/mass

5. Aya is going down the slide. Her mother gives her a push. How does the push affect her motion down the slide?

- **A.** The push decreases her speed.
- **B.** The push increases her speed.
- **C.** The push does not affect her speed.
- **D.** The push stops her downward motion.

6. What is calculated as the distance traveled per unit of time?

- **A.** work
- **B.** speed
- **C.** density
- **D.** acceleration

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ **Date** ______________

7. Circle the sentence that correctly describes the relationship between speed and time.

The faster the speed of an object, the shorter distance it can travel in a set time.

The faster the speed of an object, the less amount of time it takes to travel a set distance.

The speed of an object is equal to the amount of time it takes to travel a set distance.

The speed of an object increases as the amount of time traveled increases.

The speed of an object decreases as the time it takes to travel increases.

8. Nabila was paddling a rubber raft in the pool. Laila swam in back of the raft and began pushing it. What was the effect on the raft's motion?

A. It stopped.

B. It increased in speed.

C. It decreased in speed.

D. It moved at the same speed.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ **Date** ______________

9. A snail and a cat are in a race. The cat always travels faster than the snail. If both animals leave the starting line at the same time, which races will the cat always win?

A. only races across long distances, not short distances

B. only races across short distances, not long distances

C. races of any length

D. no races

10. Moustafa is sliding down the hill on a piece of cardboard. His sister pushes him from behind. What effect does this have on his motion?

A. He stops.

B. He speeds up.

C. He slows down.

D. His motion remains the same.

Unit 1 Concept 1

Concept Assessment
Unit 1, Concept 1: Adaptation and Survival

Name ______________________ **Date** ______________

Instructions
Please answer each question carefully.

1. What is adaptation?
   - **A.** It is a process by which organisms create offspring.
   - **B.** It is a characteristic that has changed over time to help living things survive and reproduce.
   - **C.** It is a form of pollination used by conifers.
   - **D.** It is a form of excretion that organisms with a digestive system use to get rid of waste.

2. Imagine taking some fish from coastal waters and transferring them into a deep, dark, sea cave. Which characteristics would the new fish be missing that other animals, already living in the deep sea environment, might exhibit as adaptations?

   Circle all the characteristics that apply.

Brilliant colors	Big fins	Colorless skin	More efficient gills
Good eyesight	Great hunting abilities	Poor eyesight	Thick scales

3. Which would die if it did not have the right adaptations for survival in its environment?
   - **A.** a rock
   - **B.** a car
   - **C.** an apple tree
   - **D.** a glass

Concept Assessment
Unit 1, Concept 1: Adaptation and Survival

Name ______________________ **Date** ______________

4. What happens to organisms that do not have the right adaptations for the conditions of their environment?
   - **A.** The population increases.
   - **B.** The organisms die off.
   - **C.** The population stays the same.
   - **D.** The biodiversity of the ecosystem increases.

5. How do adaptations affect the survival rate of a species?
   - **A.** Adaptations decrease the survival rate of a species.
   - **B.** Adaptations increase the survival rate of a species.
   - **C.** Adaptations change all of the organism's structures.
   - **D.** Adaptations change all of the organism's learned behaviors.

6. The growth of a plant is influenced by its adaptations to the weather conditions. A student observes that a desert plant fails to grow in humus-rich well-watered soil. The most likely reason for this is that ______.
   - **A.** humus prevents plant growth
   - **B.** a desert plant survives in less water
   - **C.** water easily drains out in a humus soil
   - **D.** a desert plant needs more nutrients in the soil for growth

7. Antelope that live in wide, open plains must adapt by using
   - **A.** thick fur which helps to keep them warm in winter.
   - **B.** long legs which help them run fast.
   - **C.** bright colors to help them attract a mate.
   - **D.** their hard outer shell to protect them.

Unit 1 Concept 2

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

Instructions
Please answer each question carefully.

1. Read the following scenario. In which part of the event is your nervous system receiving a message?
   - **A.** You touch your finger to a cactus thorn.
   - **B.** You pull your hand away.
   - **C.** You yell "Ouch!"
   - **D.** Your finger begins to bleed.

2. What are the two organs that make up the central nervous system?
   - **A.** the brain's cerebellum and the spine
   - **B.** the sympathetic and parasympathetic nervous system
   - **C.** the sensory and motor system
   - **D.** the spinal cord and the brain

3. Azza suddenly woke up and smelled something burning. She crept down the stairs to see what was happening. She found her parents reading and sitting by the fire place, which was burning wood. Why did Azza wake up?
   - **A.** The smell of the fire sent a signal through her blood cells to her brain and she woke up.
   - **B.** The smell of the fire sent a signal through her nerves to her brain and she woke up.
   - **C.** Azza's nose was stuffy from a cold and she could not sleep.
   - **D.** Azza was too cold upstairs to sleep.

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

4. Eyes squint instinctively to avoid light when bright light falls on them suddenly. Which two systems are involved in this process?
   - **A.** nervous and muscular
   - **B.** nervous and respiratory
   - **C.** circulatory and muscular
   - **D.** circulatory and respiratory

5. On a hot summer day, Malek left the pool and began to climb a ladder to his tree house. He hurt his toe by bumping it on the ladder as he climbed into the tree house. How did Malek know that he had hurt his toe?
   - **A.** The nerves in his hurt toe sent a signal through his body to his brain.
   - **B.** The blood cells in his toe sent a signal through his body to his brain.
   - **C.** Malek's toes became very cold and numb.
   - **D.** Malek's toe became smaller than before he had bumped it on the ladder.

6. Rami stopped suddenly on his bike because he heard a car speed by him. Which system received the external signal of hearing that enabled Rami to respond by stopping his bike?
   - **A.** circulatory system
   - **B.** excretory system
   - **C.** muscular system
   - **D.** nervous system

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

7. How is your nervous system like a pizza delivery restaurant?

- **A.** It needs fuel to run efficiently.
- **B.** Orders are sent out based upon the different messages that come in.
- **C.** It can take a long time for messages to be delivered and sent out.
- **D.** Not everyone sends his or her orders to the same location.

8. Match each sensory organ by drawing a line to the type of information that the organ's receptors collect.

Sensory Organ	Sensory Information
A. Hand	**1.** light coming through an open window
B. Eyes	**2.** a skunk's foul scent
C. Tongue	**3.** heat from a hot stove
D. Ears	**4.** the bitter taste of a lemon
E. Nose	**5.** a loud noise blasting from car speakers

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

9. Indicate if the following statements about the nervous system are true or false by placing a **T** (true) or **F** (false) in the column to the left.

T Nerves are constantly receiving information from the senses and sending them to the brain, even while a person is sleeping.

F When a person steps on a sharp rock with their bare foot, their brain is the last organ to react to the information.

F Each sense organ in the nervous system works on its own, independently from the brain, when the brain is busy doing other jobs for the body.

T If someone were to burn their hand, the brain can store that memory so that it can tell them to move his or her hand the next time a hot surface is nearby.

10. Students in a classroom hear a tornado siren go off. Which of the following could be ways in which they respond? Read the selections and place a check (✓) next to the correct responses.

✓ The ears sense a loud sound causing the brain to send a message for their hands to cover the ears.

____ Their noses sense something that smells bad causing the brain to send a message to students' hands to pinch their noses shut.

✓ The siren sends a message to the students' brains that causes them to remember a scary tornado event last year. It also signals their brain to send a message for the students to yell in alarm.

✓ The ears pick up noise and the brain tells the legs to jump out of the seat.

____ Students sense sound with their ears and the brain sends a message to the hands to rub their elbows in pain.

Concept Assessment
Unit 1, Concept 2: Senses at Work

Name ______________________ **Date** ______________

11. Place the sentences in order of how the information is processed by the brain. Use **1** for the statement that happens first and **4** for the statement which happens last.

2 Nerves in the body connect the sense organs to the brain.

1 Information from the environment is received by a sense organ.

4 The brain determines what to do with the information.

3 The signals travel as electrical pulses from the organ to the nerves in the brain.

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ____________________ **Date** ____________

Instructions
Please answer each question carefully.

1. Which of the following is a source of light?
- **A.** the moon
- **B.** our eyes
- **C.** fire
- **D.** a mirror

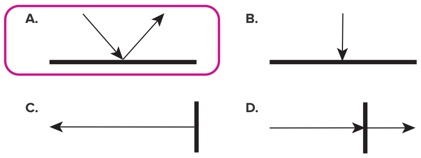
2. What property of light helps you see yourself in a mirror?
- **A.** refraction
- **B.** reflection
- **C.** absorption
- **D.** relativity

3. Which statement best explains why you can see yourself when you look at a mirror?
- **A.** Light is refracted as it passes through the mirror.
- **B.** Light is reflected, bouncing off the mirror.
- **C.** Light is refracted, bouncing off the mirror.
- **D.** Light is reflected as it passes through the mirror.

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ____________________ **Date** ____________

4. The arrows in each answer choice represent light rays. Which drawing shows how light is reflected by a mirror?



5. What type of surface scatters light unevenly?
- **A.** shiny
- **B.** rough
- **C.** smooth
- **D.** transparent

6. What word is used to describe light as it strikes a smooth, shiny surface and bounces off?
- **A.** shadow
- **B.** energy
- **C.** reflection
- **D.** wave length

7. What happens to light when it hits a rough surface?
- **A.** scattering
- **B.** reflection
- **C.** absorption
- **D.** refraction

Concept Assessment
Unit 1, Concept 3: Light and Sight

Name ____________________ **Date** ____________

8. Salma visited a lake surrounded by mountains. She observed the image of the mountains on the surface of the lake's water.

Photo Credit: Js.One / Shutterstock.com

Salma built a diorama to model what she saw. She used a postcard of a mountain scene to represent the mountains and a small mirror to represent the lake. Which is the best explanation of why her model represents what she saw?
- **A.** The mirror refracts light onto the image of the mountain on the postcard
- **B.** The mirror reflects light onto the image of the mountain on the postcard.
- **C.** The image of the mountain on the postcard is refracted by the mirror.
- **D.** The image of the mountain on the postcard is reflected by the mirror.

9. Which set of objects below would all reflect light well?
- **A.** aluminum foil, brick wall, mirror
- **B.** metal spoon, tree trunk, aluminum foil
- **C.** mirror, metal spoon, brick wall
- **D.** metal spoon, mirror, aluminum foil

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________ Date ______________

Instructions
Please answer each question carefully.

1. Imagine you are riding in a car down the highway. Read the selections and place a check (✓) next to the objects that you can look at to let you know the car is in motion.

_____ The soccer ball sitting in the seat next to you.
✓ The sign of the highway telling you the speed limit.
_____ The can of soda in the cup holder.
✓ The light pole you see out the window.
✓ The parked car that you pass on the road.

2. Read the selections and place a check (✓) next to the two sentences that describe the exertion of force on a wheelbarrow.

_____ Ziad is going to use a wheelbarrow to haul rocks from one area to another.
_____ The wheelbarrow is sitting at one end of the path.
_____ Ziad loads rocks from a pile nearby into the wheelbarrow.
_____ Once the wheelbarrow is full of rocks, they are ready to be moved to the opposite end of the path.
✓ Ziad lifts the wheelbarrow's handles and pushes it along the path.
_____ After arriving at the destination, he prepares to dump the rocks.
✓ He pushes the handles of the wheelbarrow upward so that the rocks fall out of the front.

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________ Date ______________

3. The class is playing tug of war in the courtyard. There are 10 students on either side of the rope. What would explain that no one has moved?

A. One team has more force than the other.
B. One team has half the force of the other.
C. The teams have equal and opposite forces.
D. The teams have unequal and opposite forces.

4. Review each statement below and decide if it describes a change in position, a change in both position and direction, or neither. Write the appropriate abbreviation in the column to the left of each statement.

P = change in position
PD = change in position and direction
N = neither

P A soccer ball is kicked.
N A glass sits on a table.
PD A rocket is shot up into the air then falls to the ground.
PD A moving train turns north.
P A bus travels 50 kilometers in a straight line.
PD A sailboat moving forward is pushed left by a gust of wind.

Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________ Date ______________

5. Review each statement below and decide if the motion of the objects below will be stopped by either the force of friction or by a collision with another object. Write the appropriate abbreviation in the column to the left of each statement.

F = Force of Friction
C = Collision

F A soccer ball rolls across a field.
C A car rolls into a wall.
C A pitcher throws a baseball to the catcher.
C A rugby player is tackled during a game.
F A girl on a swing eventually stops swinging.

6. Which of the following indicates motion?

A. bicycle
B. sunlight
C. running water
D. guitar string

7. Circle the two sentences about force that are true.

A force always causes movement.	Two forces can be unbalanced.
A force is a push or a pull.	Forces are only created by people.
Two forces must be equal.	A force always leads to work.

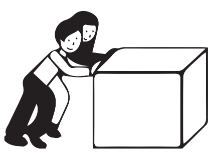
Concept Assessment
Unit 2, Concept 1: Starting and Stopping

Name ______________________ Date ______________

8. A toy car is sitting still in the driveway. Nawal kicks the car and it spins moving sideways. The car is considered in motion because ______.

A. the car was kicked
B. the car did a wheelie
C. the car has four wheels
D. the position of the car changed

9. Fatma is pushing a big box. Ezz comes to help her.



How does this change the force and motion of the box?

A. It does not change the force or the motion.
B. It increases the force and decreases the motion.
C. It increases the force and increases the motion.
D. It decreases the force and increases the motion.

10. Heba notices that the position of her golf ball on the green has changed in comparison to the flagpole in the hole. This change is a result of ______.

A. motion of the flagpole
B. motion of the ball
C. speed of the ball
D. speed of the flagpole

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________ **Date** ______________

Instructions
Please answer each question carefully.

1. When gasoline is burned, stored chemical energy is released in the form of ______ and light.
   - **A.** fumes
   - **B.** carbon dioxide
   - **C.** sparks
   - **D.** heat

2. You toss a ball into the air. The ball falls and then bounces back into the air. What happens to its energy?
   - **A.** All of the energy remains unchanged.
   - **B.** More energy is created as the ball bounces.
   - **C.** Some energy is destroyed as the ball bounces.
   - **D.** Some energy changes to other forms of energy.

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________ **Date** ______________

3. There are lots of ways one form of energy can be transformed into another form.

   Draw a line to match the action with the correct energy transformation. *Each action will match an energy transformation. Not all of the energy transformations will have a match to an action.*

Action	Energy Transformation
A. Dalia lifts a bowling ball to the top of a slide.	**1.** motion → sound
B. The ball begins to roll down the slide.	**2.** chemical → electrical
C. The rolling ball makes a lot of noise on the metal slide.	**3.** gravitational potential → motion
D. The ball strikes the head of a nail which gets pounded into a piece of wood, heating the nail and wood a little.	**4.** motion → gravitational potential
	5. motion → thermal
	6. motion → light

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   - **A.** It becomes sound energy and heat energy.
   - **B.** It becomes potential energy and solar energy.
   - **C.** Some is lost, and some becomes sound energy.
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Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________ **Date** ______________

5. Which ball has kinetic energy but not potential energy?
   - **A.** a ball rolling down a ramp
   - **B.** a ball sitting on a high shelf
   - **C.** a ball bouncing up and down
   - **D.** a ball rolling on a flat sidewalk

6. Which type of energy change occurs when a person rides a bike?
   - **A.** heat energy changes to potential energy
   - **B.** chemical energy changes to kinetic energy
   - **C.** solar energy changes to chemical energy
   - **D.** kinetic energy changes to nuclear energy

7. Which of the following can store energy?
   - **A.** battery
   - **B.** wire
   - **C.** plastic
   - **D.** rubber

Concept Assessment
Unit 2, Concept 2: Energy and Motion

Name ______________ **Date** ______________

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Chemical	Motion	Light
Sound	Electricity	

Sound	You hear a dog barking at a cat.
Electricity	Your cell phone uses a battery.
Motion	A girl roller skates on the sidewalk.
Chemical	Your body uses glucose for energy.
Light	You see lights coming towards you.
Chemical	Gasoline explodes inside a bus engine.
Electricity	You use a flashlight on a camping trip.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ Date ______________

Instructions
Please answer each question carefully.

1. Read each situation below and decide if the speed of the object will increase or decrease, based on the force that is applied to it. Write INCREASE or DECREASE in the column on the left.

Increase A sailboat gets pushed from behind by a gust of wind.
Decrease A ball rolls into a wall.
Increase A soccer ball is kicked.
Decrease A man pulls on the leash of a dog, as the dog tries to run away.
Increase A pitcher throws a baseball.

2. Read the statements below to determine the ones that give enough information to calculate the speed of the object. Place a check (✓) next to the statements apply.

_____ A boy ran 4 kilometers on a cold and windy morning.
✓ A car was able to travel 200 kilometers in 4 hours.
_____ A plane was in the air for 6 hours and went higher than 8,000 meters.
✓ A horse ran around the 2-kilometer racetrack in 2 minutes.
_____ A boat traveled 4 kilometers across the lake when the temperature was 13°C.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ Date ______________

3. How is speed measured?
- **A.** distance traveled per unit of time
- **B.** time per unit of distance traveled
- **C.** mass per unit of distance traveled
- **D.** volume per unit of mass

4. Which formula can be used to calculate speed?
- **A.** distance/time
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- **A.** work
- **B.** speed
- **C.** density
- **D.** acceleration

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ Date ______________

7. Circle the sentence that correctly describes the relationship between speed and time.

The faster the speed of an object, the shorter distance it can travel in a set time.

The faster the speed of an object, the less amount of time it takes to travel a set distance.

The speed of an object is equal to the amount of time it takes to travel a set distance.

The speed of an object increases as the amount of time traveled increases.

The speed of an object decreases as the time it takes to travel increases.

8. Nabila was paddling a rubber raft in the pool. Laila swam in back of the raft and began pushing it. What was the effect on the raft's motion?
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- **B.** It increased in speed.
- **C.** It decreased in speed.
- **D.** It moved at the same speed.

Concept Assessment
Unit 2, Concept 3: Speed

Name ______________________ Date ______________

9. A snail and a cat are in a race. The cat always travels faster than the snail. If both animals leave the starting line at the same time, which races will the cat always win?
- **A.** only races across long distances, not short distances
- **B.** only races across short distances, not long distances
- **C.** races of any length
- **D.** no races

10. Moustafa is sliding down the hill on a piece of cardboard. His sister pushes him from behind. What effect does this have on his motion?
- **A.** He stops.
- **B.** He speeds up.
- **C.** He slows down.
- **D.** His motion remains the same.

Name ____________________

T-Chart

Topic ____________________

Name ______________________________

Claim, Evidence, Reasoning

My Question A question I want to answer	**My Claim** The answer to my question

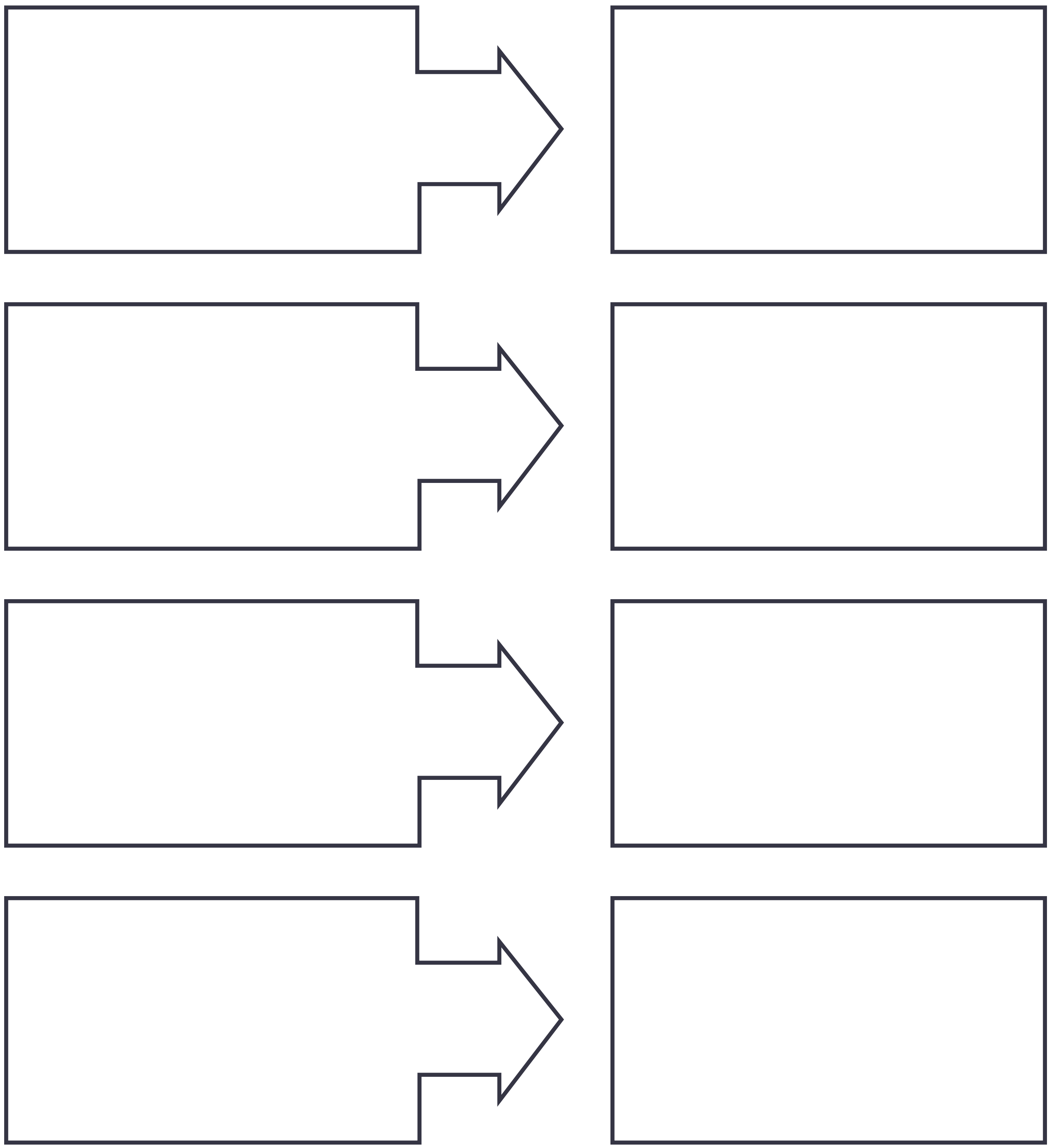
Evidence I Collected Data and evidence I collected from video, reading, interactives, and hands-on activities	**Reasoning That Supports My Claim** Why my answer is correct

Name ______________________________

Cause / Effect

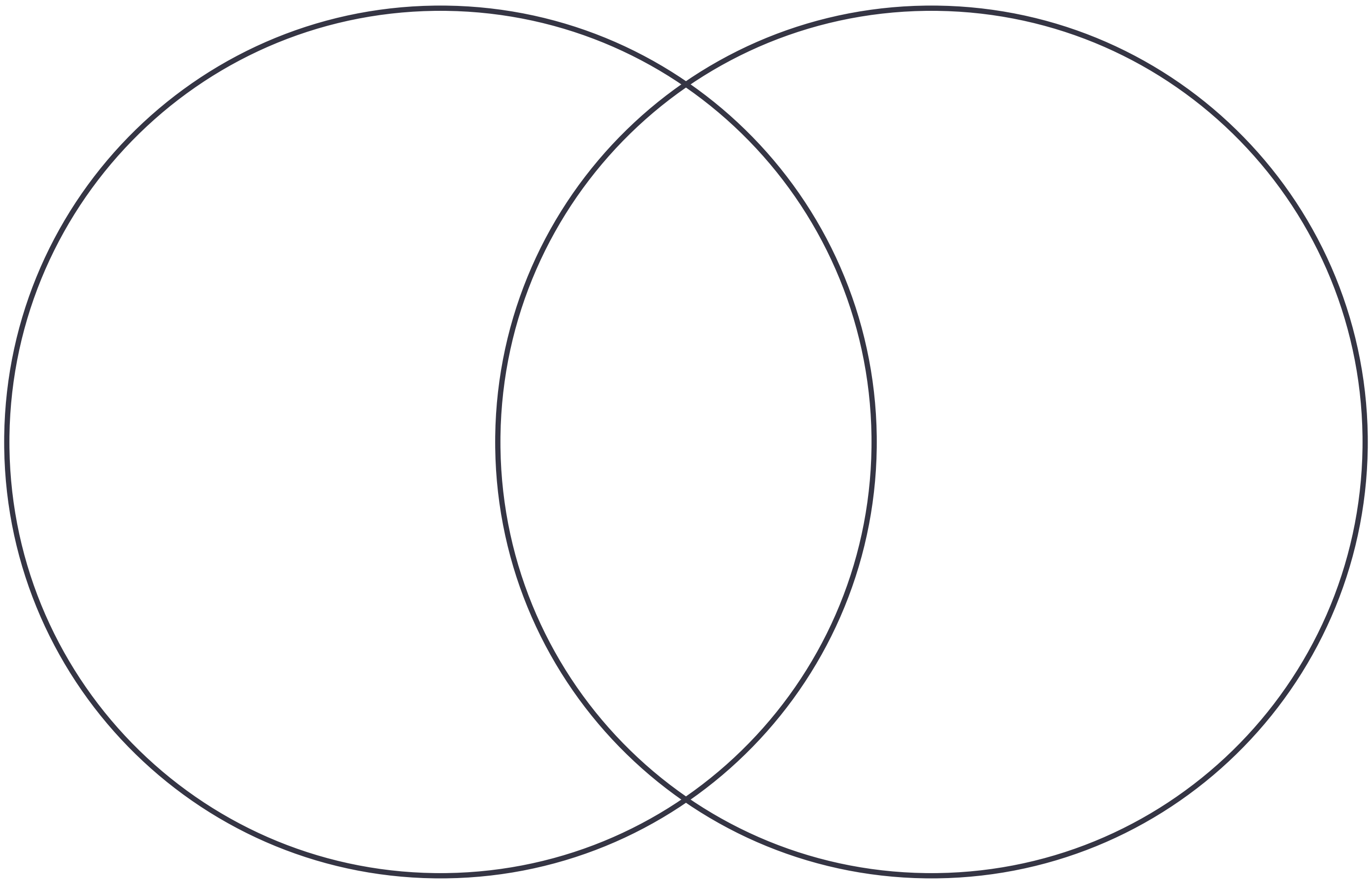
Topic ______________________________

Cause | Effect



Name ______________________________

Venn Diagram



Following common safety practices is the first rule of any laboratory or field scientific investigation.

Dress for Safety

One of the most important steps in a safe investigation is dressing appropriately.

- Use gloves to protect your hands and safety goggles to protect your eyes when handling chemicals, liquids, or organisms.
- Wear proper clothing and clothing protection. Tie back long hair, roll up long sleeves, and if they are available, wear a lab coat or apron over your clothes. Always wear close-toed shoes. During field investigations, wear long pants and long sleeves.

Safety Goggles

Be Prepared for Accidents

Even if you are practicing safe behavior during an investigation, accidents can happen. Learn the emergency equipment location if available and how to use it.

Most importantly, when an accident occurs, immediately alert your teacher and classmates. Do not try to keep the accident a secret or respond to it by yourself. Your teacher and classmates can help you.

Practice Safe Behavior

There are many ways to stay safe during a scientific investigation. You should always use safe and appropriate behavior before, during, and after your investigation.

- Read all of the steps of the procedure before beginning your investigation. Make sure you understand all the steps. Ask your teacher for help if you do not understand any part of the procedure.
- Gather all your materials and keep your workstation neat and organized. Label any chemicals you are using.
- During the investigation, be sure to follow the steps of the procedure exactly. Use only directions and materials that have been approved by your teacher.
- Eating and drinking are not allowed during an investigation. If asked to observe the odor of a substance, do so using the correct procedure known as wafting, in which you cup your hand over the container holding the substance and gently wave enough air toward your face to make sense of the smell.
- When performing investigations, stay focused on the steps of the procedure and your behavior during the investigation. During investigations, there are many materials and equipment that can cause injuries.
- Treat animals and plants with respect during an investigation.
- After the investigation is over, appropriately dispose of any chemicals or other materials that you have used. Ask your teacher if you are unsure of how to dispose of anything.
- Make sure that you have returned any extra materials and pieces of equipment to the correct storage space.
- Leave your workstation clean and neat. Wash your hands thoroughly.

A

adaptation
a behavior or physical feature that has changed over time to help an organism survive in its environment (related word: adapt)

air
the part of the atmosphere closest to Earth; the part of the atmosphere that organisms on Earth use for respiration

antenna
a device that receives radio waves and television signals

Arctic
being from an icy climate, such as the north pole

B

behavior
all of the actions and reactions of an animal or a person (related word: behave)

brain
the main control center in an animal body; part of the central nervous system

C

camouflage
the coloring or patterns on an animal's body that allow it to blend in with its environment

canyons
deep valleys carved by flowing water

chemical energy
energy that can be changed into motion and heat

chemical weathering
changes to rocks and minerals on Earth's surface that are caused by chemical reactions

code
information transformed into another, representative, form (such as using dots and dashes to represent letters)

collision
the moment where two objects hit or make contact in a forceful way

conserve
to protect something, or prevent the wasteful overuse of a resource

Glossary

contour lines
lines drawn on a map to show places of stable versus changing elevation- lines that are closer together represent steeper topography, while lines that are farther apart represent flatter areas

convert (v)
to change forms

D

delta
a fan-shaped mass of mud and other sediment that forms where a river enters a large body of water

deposition
laying sediment back down after erosion moves it around

digestive system
the body system that breaks down food into tiny pieces so that the body's cells can use it for energy

digital
a signal that is not continuous and is made up of tiny separate pieces

dune
a hill of sand created by the wind

E

Earth
the third planet from the sun; the planet on which we live (related words: earthly; earth – meaning soil or dirt)

earthquake
a sudden shaking of the ground caused by the movement of rock underground

ecosystems
all the living and nonliving things in an area that interact with each other

electromagnetic spectrum
the full range of frequencies of electromagnetic waves

elevation
the height of an area of land above sea level

energy
the ability to do work or cause change; the ability to move an object some distance

energy source
where a form of energy begins

energy transfer
the transfer of energy from one organism to another through a food chain or web; or the transfer of energy from one object to another, such as heat energy

engineer
Engineers have special skills. They design tools or technologies that help solve problems.

erosion
the removal of weathered rock material. After rocks have been broken down, the small particles are transported to other locations by wind, water, ice, and gravity.

erupt
the action of lava coming out of a hole or crack in Earth's surface; the sudden release of hot gasses or lava built up inside a volcano (related word: eruption)

extinct
describes a species of animals that once lived on Earth but which no longer exists (related word: extinction)

F

feature
things that describe what something looks like

force
a pull or push that is applied to an object

forecast
(v) to analyze weather data and make an educated guess about weather in the future; (n) a prediction about what the weather will be like in the future based on weather data

fossil fuels
fuels that come from very old life forms that decomposed over a long period of time, like coal, oil, and natural gas

friction
a force that slows down or stops motion

fuels
any materials that can be used for energy

G

generate
to produce by turning a form of energy into electricity

geothermal
heat found deep within Earth

glacier
a large sheet of ice or snow that moves slowly over Earth's surface

gravitational potential energy
energy stored in an object based on its height and mass

gravity
the force that pulls an object toward the center of Earth (related word: gravitational)

H

heat
the transfer of thermal energy

hibernate
to reduce body movement during the winter in an effort to conserve energy (related word: hibernation)

hydroelectric energy
electricity generated by moving water flowing over and spinning a turbine

I

information
facts or data about something; the arrangement or sequence of facts or data

K

key
a tool on a map used to explain symbols and provide scale

kinetic energy
the energy an object has because of its motion

L

landforms
large natural structures on Earth's surface, such as mountains, plains, or valleys

lava
molten rock that comes through holes or cracks in Earth's crust that may be a mixture of liquid and gas but will turn into solid rock once cooled

light
a form of energy that moves in waves and particles and can be seen

M

magma
melted rock located beneath Earth's surface

magnetic field
a region in space near a magnet or electric current in which magnetic forces can be detected

map
a flat model of an area

mass
the amount of matter in an object

matter
material that has mass and takes up some amount of space

migration
the movement of a group of organisms from one place to another, usually due to a change in seasons

minerals
natural, nonliving solid crystal that makes up rocks

model
a drawing, object, or idea that represents a real event, object, or process

motion
when something moves from one place to another (related words: move, movement)

mountains
areas of land that form a peak at a high elevation (related term: mountain range)

N

nerve
a cell of the nervous system that carries signals to the body from the brain, and from the body to the brain and/or spinal cord

nonrenewable
once it is used, it cannot be made or reused again

nonrenewable resource
a natural resource of which a finite amount exists, or one that cannot be replaced with currently available technologies

O

ocean
a large body of salt water that covers most of Earth

opaque
describes an object that light cannot travel through

organism
any individual living thing

P

physical map
a type of map which illustrates the physical features found in an area such as mountains and bodies of water

Glossary

political map
a type of map which illustrates the political boundaries within an area such as countries or cities

pollute
to put harmful materials into the air, water, or soil (related words: pollution, pollutant)

pollution
when harmful materials have been put into the air, water, or soil (related word: pollute)

potential energy
the amount of energy that is stored in an object; energy that an object has because of its position relative to other objects

predator
an animal that hunts and eats another animal

predict
to guess what will happen in the future (related word: prediction)

prey
an animal that is hunted and eaten by another animal

pupil
the black circle at the center of an iris that controls how much light enters the eye

R

radiation
electromagnetic energy (related word: radiate)

receptor
nerves located in different parts of the body that are especially adapted to receive information from the environment

reflect
light bouncing off a surface (related word: reflection)

reflex
an automatic response

remote (adj)
to be operated from a distance

renewable
to reuse or make new again

renewable resource
a natural resource that can be replaced

reproduce
to make more of a species; to have offspring (related word: reproduction)

resistance
when materials do not let energy transfer through them

respiratory system
the system of the body that brings oxygen into the body and releases carbon dioxide

rock cycle
the process during which rocks are formed, change, wear down, and are formed again over long periods of time

S

satellite
a natural or artificial object that revolves around another object in space

sediment
solid material, moved by wind and water, that settles on the surface of land or the bottom of a body of water

seismic
having to do with earthquakes or earth vibrations

senses
taste, touch, sight, smell, and hearing (related word: sensory)

soil
the outer layer of Earth's crust in which plants can grow; made of bits of dead plant and animal material as well as bits of rocks and minerals

sound
anything you can hear that travels by making vibrations in air, water, and solids

sound wave
a sound vibration as it is passing through a material; most sound waves spread out in every direction from their source

speed
the measurement of how fast an object is moving

sun
any star around which planets revolve

survive
to continue living or existing: an organism survives until it dies; a species survives until it becomes extinct (related word: survival)

system
a group of related objects that work together to perform a function

Glossary

T

tectonic plate
one of several huge pieces of Earth's crust

thermal energy
energy in the form of heat

topographic map
a map that shows the size and location of an area's features such as vegetation, roads, and buildings

trait
a characteristic or property of an organism

transparent
describes materials through which light can travel; materials that can be seen through

turbine
a machine designed to spin in a stream of moving water, steam, or wind that is often used in generating electricity

V

valley
a low area of land between two higher areas, often formed by water

volcano
an opening in Earth's surface through which magma and gases or only gases erupt (related word: volcanic)

W

water
a compound made of hydrogen and oxygen; can be in either a liquid, ice, or vapor form and has no taste or smell

watermills
structures that use a turbine or water wheel to harness the kinetic energy of moving water to operate machinery or as a step in the generation of electricity

watershed
a region in which all precipitation and surface water collects and drains into the same river

wave
a disturbance caused by a vibration; waves travel away from the source that makes them

weathering
the physical or chemical breakdown of rocks and minerals into smaller pieces or aqueous solutions on Earth's surface

windmills
structures that use blades placed at an angle around a fixed point to convert the kinetic energy of wind into energy that can operate machinery or generate electricity

work
a force applied to an object over a distance

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Science Term 1

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